AD NUMBER
ADB028222
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; 08 JUN 1992. Other requests shall be referred to Army Chemical Research Development and Engineering Center, ATTN: SMCCR-SPS-T, Aberdeen Proving Ground, MD 21010-5423. This document contains export-controlled technical data.**
AUTHORITY
ECBC memo dtd 18 Feb 2016

AD NUMBER

ADB028222

NEW LIMITATION CHANGE

TO

Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; 8 Jun 1992. Other requests shall be referred to Commander, Army Chemical RD&E CTR., Attn: SMCCR-SPS-T, Aberdeen Proving Ground, MD 21010-5423.

FROM

Distribution authorized to U.S. Gov't. agencies only; test and evaluation; Dec 1974. Other requests shall be referred to Command/Director, Attn: DRDAR-CLJ-R., Aberdeen Proving Ground, MD 21010.

AUTHORITY

Per DTIC fm 55

EDGEWOOD ARSENAL SPECIAL REPORT

EO-SR-74001

CHEMICAL AGENT DATA SHEETS

VOLUME I

DECEMBER 1974

DEPARTMENT OF THE ARMY
Headquarters, Edgewood Arsenal
Aberdeen Proving Ground, Maryland 21010

Use of Laboratory Animals

In conducting the research described in this report, the investigators adhered to the "Guide for the Care and Use of Laboratory Animals," as set forth by the Committee on Revision of the Guide for Laboratory Animal Facilities and Care of the Institute of Laboratory Animal Resources - National Research Council.

Disclaimer

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents. These Chemical Data Sheets are for Surety Purposes and may not be referenced in technical reports.

Disposition

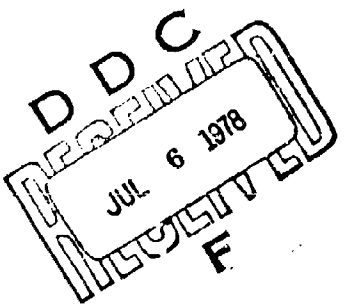
Destroy this report when it is no longer needed. Do not return it to the originator.

EDGEWOOD ARSENAL SPECIAL REPORT

EO-SR-74001

CHEMICAL AGENT DATA SHEETS

VOLUME I



DECEMBER 1974

DEPARTMENT OF THE ARMY
Headquarters, Edgewood Arsenal
Aberdeen Proving Ground, Maryland 21010

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: EO-SR-74001
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): CHEMICAL AGENT DATA SHEETS, Volume I,
5. TYPE OF REPORT & PERIOD COVERED: Special Report, Dec[redacted] 1973-Dec[redacted] 1974.
6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)
8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: COMMANDER, Edgewood Arsenal, Attn: SAREA-SR, Aberdeen Proving Ground, MD 21010
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS
12. REPORT DATE: Dec[redacted] 1974
13. NUMBER OF PAGES: 165 p.
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
15. SECURITY CLASS. (of this report): UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to US Government agencies only. This Special Report covers test and evaluation of toxic agents. Other requests for this document must be referred to Commander, Edgewood Arsenal, Attn: [redacted] Aberdeen Proving Ground, Maryland 21010. DRDAR-CLJ-R

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

These Chemical Data Sheets are for Surety Purposes and may not be referenced in technical reports.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Chemical Agents	Incapacitating Agents
Blister Agents	Nerve Agents
Blood Agents	Lacrimators
Choking Agents	Sternutators

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This manual is a reference handbook published for use as a chemical agent information source by personnel performing services within chemical agent areas. (See SHUEA Regulation 70-4, Chemical Agent and Simulant Data Sheets.)

404 007

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

PREFACE

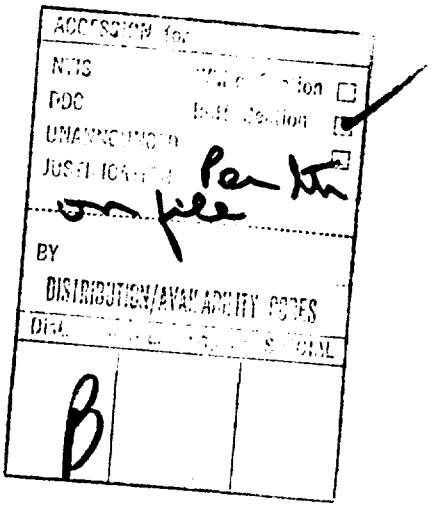
These Chemical Agent Data Sheets were prepared by the Director, Development and Engineering Directorate, at the request of and under the guidance and control of the US Army Surety Office, Edgewood Arsenal, Aberdeen Proving Ground, Maryland.

The Chief, Surety Office, initiated the program by Disposition Form to responsible elements for information sheets for 41 chemical agents. The information sheets contained 47 chemical, physical, and physiological properties for each agent. Input was received from the Director, Chemical Laboratory, Director, Biomedical Laboratory, Director, Manufacturing Technology, Director, Development and Engineering, and Chief, Safety Office.

Scientific and technical personnel of Edgewood Arsenal were assigned the task of researching and preparing the draft manuscript. The following persons are gratefully acknowledged for their dedicated performance of this task:

Messrs. Andrew W. Anderson, H. H. Baker, and Walter J. Majerle of the Surety Office; Messrs. Phillip M. Edwards and J. F. Voeglein, Jr., Safety Office; Mr. Stanley R. Kramer, Manufacturing Technology Directorate; Messrs. John J. Callahan, John B. Samuel, and David Schneck, Chemical Research Division, Chemical Laboratory; Ms. Dorothy Ward, Nellie Anson, Audrey Harmeyer, and Mr. Lester L. Miller, Biomedical Laboratory.

The document is prepared in two volumes. Volume I is unclassified and contains 18 agents. Volumn II, which is Confidential, contains 23 agents.



CONTENTS

Next page is blank.

CHEMICAL AGENT DATA SHEETS

CHAPTER 1

INTRODUCTION

1. Purpose and Scope. This manual is a reference handbook published for use as a chemical agent information source by personnel performing services within chemical agent areas. (See SMUEA Regulation 70-4, Chemical Agent and Simulant Data Sheets.)

2. Definitions. a. The following terms are defined as they apply to military use of chemical agents:

(1) Blister Agents - affect eyes and lungs and blister the skin. Appear as colorless to dark brown oil liquid droplets; invisible in vapor form. Effective in small quantities; produce delayed casualties. Some are odorless, some smell like horseradish or garlic; others have a biting odor.

(2) Blood Agents - disseminated as gases or vapors and are inhaled. These agents prevent the cells from using the oxygen in the blood, which causes convulsions and coma. The agents are colorless as gases and may have a faint odor of peach kernels.

(3) Choking Agents - disseminated as gases and are inhaled. They cause the lungs to fill with liquid. The effects, which may be delayed 2 to 24 hours, include coughing, choking, tightness in the chest, nausea, headache, rapid and shallow breathing, fatigue, shock, and death. These gases are colorless and smell like new-mown hay.

(4) Incapacitating Agents - disseminated as aerosols and are inhaled. They alter or disrupt the higher regulatory activity of the central nervous system to produce temporary physiological or mental effects that prevent individuals from performing their duties for hours or days. They do not seriously endanger life except at doses exceeding many times the effective dose, and produce no permanent injury.

(5) Nerve Agents - directly affect the nervous system and are highly toxic in both liquid and vapor forms. These agents, whether absorbed through the skin or inhaled, usually lead to convulsions and death. Nerve agents are usually odorless, colorless, and tasteless.

b. Training and riot control agents are not chemical agents in the sense that they are not used to permanently incapacitate, injure, or kill. These agents, several of which are documented in this manual, are defined as follows:

(1) Lacrimators (Tear Agents) - disseminated in the air as vapor or smoke. They act primarily on the eyes to produce intense pain.

(2) Sternutators (Sneezing and Vomiting Agents) - dispersed as aerosols and produce their effects by inhalation or direct contact. They cause violent sneezing, coughing, nausea, and vomiting, and a general feeling of malaise.

3. Grouping of Chemical Agents. a. General. Chemical agents are grouped according to their use, their physiological actions, and their physical and chemical properties.

b. Use. Military chemical agents are categorized according to their use, as follows:

(1) Toxic Chemical Agents (Casualty Agents). Agents capable of producing serious injury or death when used in field concentrations. They include nerve agents, vesicants, lung irritants, and systemic poisons.

(2) Incapacitating Agents. Agents that produce temporary physiological or mental effects, or both, which will render personnel incapable of performing their assigned duties for hours or days.

(3) Training and Riot Control Agents. Agents that produce only a temporary irritating or incapacitating effect when used in field concentrations. These include the sternutators, vomiting agents, and lacrimators.

c. Physiological Actions. The toxic chemical agents, the incapacitating agents, and the training and riot control agents are categorized according to their physiological actions. These actions, by agent type, are:

(1) Blister Agents (Vesicants) - Agents readily absorbed by both exterior and interior parts of the body, causing inflammation, blisters, and general destruction of tissues. The vapors, in addition to affecting the skin, attack the respiratory tract; the effects are usually more severe in the upper tract. Eyes are very susceptible to blister agents.

(2) Blood Agents (Systemic Poisons) - Agents which, when absorbed into the body - primarily by inhalation, affect bodily functions through action on the oxygen-carrying properties of the blood and interfere with normal transfer of oxygen from lungs via the blood to body tissues.

(3) Choking Agents (Lung Irritants) - Agents which irritate and inflame the bronchial tubes and lungs and cause pulmonary edema and secondary pneumonia. Their effects are limited to the respiratory tract, with injury extending to the deepest part of the lungs.

(4) Incapacitating Agents - Agents which act as central nervous system depressants. Their effects range from stumbling or staggering, vomiting and hallucinations, to loss of memory, inability to concentrate or comprehend, and delirium or coma.

(5) Nerve Agents - Agents which, when inhaled, ingested, or absorbed through the skin, react irreversibly to permit excessive concentrations of acetycholine at the endings of the parasympathetic nerves, the motor nerves to voluntary muscle, nerves to autonomic ganglia, endings to sympathetic nerves to sweat glands, and the central nervous system. The passage of nerve impulses is interrupted and essential body functions, such as breathing, vision, and muscular control are disturbed.

(6) Training or Riot Control Agents - Agents which, through inhalation or direct contact, produce local irritation of the upper respiratory tract, the nasal passages, and the eyes. They cause tearing, sneezing, coughing, nausea, and vomiting, chest pains, and mental depression.

d. Physical and Chemical Properties. These properties define the physical state of the agent. Chemical agents may exist as solids, liquids, or gases. To a certain extent, the state in which an agent normally exists determines its use, duration of effectiveness, physiological action, and the type of munition used for its dissemination.

4. Data Organization. Items 4 through 17 are the physiological data for each agent. Items 18 through 47 are the chemical and physical characteristics of each agent.

Next page is blank.

CHAPTER 2

SPECIFIC CHEMICAL AGENTS AND THEIR PROPERTIES

The physiological effects and the physical and chemical properties of the most significant military chemical agents are described. Information is also given on their detection and decontamination and on self aid or first aid. Brief information on their transportation and storage is also included.

5. Blister Agents. Blister agents are chemicals of relatively low volatility that have a blistering effect upon the skin, eyes, and lung tissue. Most blister agents are insidious in action; there is little or no pain at the time of exposure, except to Lewisite (L) and phosgene oxime (CX) which cause immedate pain on contact. The development of casualties may be delayed. Protection from blister agents is extremely difficult since they attack any part of the body which comes in contact with the liquid or vapor. This group of toxic agents includes the arsenicals (arsenic is the central atom) and the mustards and mustard mixtures.

Blister agents described in this volume are:

CX (Dichloroformoxime or Phosgene Oxime)

ED (Dichloroethylarsine)

H (Levinstein Mustard)

HD (Bis (2-chloroethyl) Sulfide, Distilled Mustard)

HN-3 (Nitrogen Mustard-3)

HT (60% HD and 40% T by weight)

L (Dichloro-2-chlorovinylarsine, Lewisite)

PD (Dichlorophenylarsine)

Next page is blank.

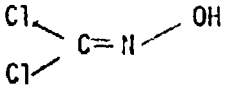
1. Chemical Code or EA Number: CX

2. Chemical Name: Dichloroformoxime or Phosgene Oxime.

3. Chemical Formulae:

   a. Empirical. $CHCl_2NO$

   b. Structural.



4. Biological Type Compound:

Urticant; produces instant, almost intolerable pain and local tissue destruction immediately on contact with skin and mucous membranes. This is characteristic of a corrosive injury.

5. Principal Pharmacological Action:

Local lesion believed caused by liberation of hydrochloric acid (or acid character of phosgene oxime), leading to alterations in physicochemical properties of tissue.

Causes violent irritation to eyes, skin, respiratory tract, and all mucous membranes; produces immediate pain which varies from mild prickling to severe bee sting. Its action on the skin is corrosive.

6. Characteristic Odor: Intense, penetrating, disagreeable.

7. Effective Routes of Administration: Inhalation, percutaneous, ocular, ingestion, injection.

8. Median Lethal Dosage, Man (LCt_{50}'s):

   a. Inhalation. 3200 mg min/m^3 (estimated).

9. Median Lethal Dosage, Animal:

   a. Inhalation (LCt_{50}'s).

      Mouse. All concentrations are nominal; all exposure periods are for 10 minutes.

Dichloroformoxime or Phosgene Oxime.

48-hour observation period, 10,000 ± 1500 mg min/m^3.

10-day observation period, 7000 mg min/m^3.

15-day observation period, SI < 7000 mg min/m^3.

Rat. >11,900 mg min/m^3 (t = 10). Nominal concentration, 10-day observation period.

Guinea Pig. 9200-11,900 mg min/m^3 (t = 10). Nominal concentration, 10-day observation period.

Rabbit. >11,900 mg min/m^3 (t = 10). Nominal concentration, 10-day observation period.

Cat. 6800-11,900 mg min/m^3 (t = 10). Nominal concentration, 10-day observation period.

b. Percutaneous (LD_{50}'s).

Guinea Pig. 25 mg/kg (70% aqueous solution)

Rabbit. 14.1 mg/kg (75% proplylene glycol solution). Depilated skin.

26.9 mg/kg (75% aqueous solution). Depilated skin.

27.8 mg/kg (50% aqueous solution).

c. Intravenous (LD_{50}'s).

Rabbit. 2.00 (1.48-2.70) mg/kg (propylene glycol solution).

2.82 (2.24-3.55) mg/kg (aqueous solution).

d. Oral (LD_{50}'s).

Rat. 40-70 mg/kg (approximate)

e. Subcutaneous (LD_{50}'s).

Guinea Pig. 15 mg/kg (approximate)

10. Median Incapacitating Dosage: No data.

11. Threshold Limit Value: No data.

12. Minimum Effective Dosage, Man (Skin):

a. Vapor.

Ct: 255 mg min/m^3 (t = 4.5). Only one subject. First stinging sensation.

Ct: 365 mg min/m^3 (t = 2.5). Only one subject. Painful sensation.

b. Liquid.

Data on low doses:

No. of subjects	Amount of CX	Effects, remarks
7	1 µg (10 µl of 0.01% acetone solution)	No effects.
7	10 µg (10 µl of 0.1% acetone solution)	6/7 no effects. 1/7 slight redness.
7	45 µg (ca 0.28 µl of 16% aqueous solution)	5/7 definite itching and warmth; 2/7 pain or distress. Droplets applied by micrometer syringe onto volar forearm.
Unknown	200 µg (benzene solution)	Minimum amount required to damage 1 sq cm of skin.

13., 14., & 15. Physiological Effects (Acute and Chronic) and Onset Time of Symptoms, Man:

a. Eyes.

CX vapors are violently irritating to the eyes. Very low concentrations can cause inflammation, lacrimation, and temporary blindness; higher concentrations can cause corneal corrosion and dimming of vision. One investigator suffered recurrent corneal erosions which developed 24 hours after a short exposure incurred while spreading the compound on an unglazed plate under a hood. This condition, accompanied by a sharp loss in visual acuity and copious lacrimation, lasted 2 days with diminishing intensity, and vision returned to normal after about a week.

Dichloroformoxime or Phosgene Oxime.

b. Skin.

Skin lesion is of the corrosive type. It is characterized by the appearance within 30 seconds of a central blanched area surrounded by an erythematous ring. Subcutaneous edema follows in about 15 minutes. After 24 hours, the central blanched area becomes necrotic and darkened, and an eschar is formed in a few days. Healing is accompanied by sloughing of the scab. Itching may be present throughout healing.

16. Self Aid and First Aid:

Because of the rapid reaction of phosgene oxime with tissue, decontamination will not be entirely effective after pain has been produced. Despite that, the contaminated area should be flushed as rapidly as possible with copious amounts of water to remove any phosgene oxime which has not yet reacted with tissue.

17. Tolerable Environmental Concentrations to Uncontrolled Population:

No data.

18. Molecular Weight: 113.9

19. Purity Range:

a. Laboratory Sample.

b. Plant Sample. 1970-85 wt%; 1955-92 to 95 wt%.

20. Physical Appearance: Colorless, crystalline, deliquescent. Solid at room temperature.

21. Vapor Density, Relative to Air: 3.9

22. Liquid Density: No data.

23. Solid Density

a. Bulk Density. Not available.

b. Crystal Density. Not available.

24. Normal Freezing Point or Melting Point: 35 to 40° C.

25. Boiling Point: 128° C with decomposition.

26. Vapor Pressure: 11.2 mm Hg @ 25° C. for solid (sublimation). 13 mm Hg @ 40° C. (liquid).

27. Volatility: 7.6 x 104 mg/m3 at 40° C.

28. Viscosity: Not available.

29. Flash Point: Unknown.

30. Autoignition Temperature: Unknown.

31. Latent Heat of Vaporization: 101 cal/g @ 40° C.

32. Latent Heat of Fusion: Unknown.

33. Vapor-Air Explosive Hazard Range: Not available.

34. Relative Persistency:

    a. Soil. Approximately 2 hours.

    b. Surface (Wood, Metal, Masonry, Rubber, Paint). Relatively nonpersistent.

    c. Water. Relatively nonpersistent.

35. Solubility (g/100 g solvent):

    a. Water (distilled). Forms hydrate which is very soluble in water, (~ 70%).

    b. Other. Very soluble in most organic solvents.

    c. Best Solvent. Water.

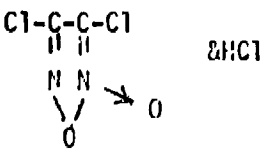
36. Thermal Decomposition Rate (half-life):

    Gradually decomposes at reflux (129° C); decomposes on storage above -20° C.

37. Heat of Combustion: Unknown.

38. Products of Combustion:

    Products of thermal decomposition:



Furoxane

Dichloroformoxime or Phosgene Oxime.

39. Rate of hydrolysis (specify half-life): Very slow in H_2O at pH7; 5% decomposition in 6 days at room temperature. Reacts violently in alkaline solution.

40. Hydrolysis Products:

Monohydrate. H
In hot acid, CO_2, $[NH_2OH]^{-+}$ Cl and HCl

41. Corrosive Properties: Corrosive to most metals.

42. Detection Methods and Equipment:

For Vapor: M15A2A, M18A2, M19 kits.
(DB-3 Test - blue band detector tube)
M8 Alarm

For Solid: ABC-M8 detector paper.

43. Decontaminants:

a. Personnel. Large amounts of water.

b. Equipment. Large amounts of water or DS2. Decontamination is not entirely effective.

c. Areas (Terrain). Spray with water from M9 or M12A1 decontaminating apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

a. Laboratory Sample. 1, 2 dimethoxybenzene, ether, dioxane, nitromethane, glycine, and acetylacetate (5% wt%).

b. Plant Sample. Same.

46. Types of Containers Required for Storage: Glass or enamel-lined storage vessels. Extremely unstable in metal; iron chloride may cause explosive decomposition.

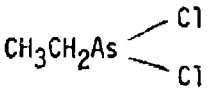
47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: Unknown.

1. Chemical Code or EA Number: ED

2. Chemical Name: Dichloroethylarsine

3. Chemical Formulae:

   a. Empirical. $CH_3CH_2AsCl_2$

   b. Structural. 

4. Biological Type Compound: Lethal agent.

5. Principal Pharmacological Action:

The toxic chlorarsine derivatives produce effects which are qualitatively similar to those produced by Lewisite (q.v.) but which differ in degree. Thus, they are all irritant to the respiratory tract and produce lung injury on sufficient exposure. The vapors are irritating to the eyes and the liquids may produce serious eye lesions. The absorption of either vapor or liquid through the skin in adequate dosage may lead to systemic intoxication or death. Local skin damage leading to vesication in man is usually produced by sufficient exposure to the vapor or by contact with the liquid. Its rate of detoxification in sublethal amounts is rapid.

6. Characteristic Odor: Fruity, but biting and irritating.

7. Effective Routes of Administration: Inhalation, percutaneous, ocular, ingestion, and injection.

8. Median Lethal Doses, Man (LCt_{50}'s):

   a. Inhalation. 3000-5000 mg min/m^3. Since ED is detoxified by the body at an appreciable rate, the product of concentration and time is not constant. As t increases, C_3 does not decrease proportionately. For example, exposure to 40 mg/m^3 for 75 minutes might have an affect similar to exposure to 30 mg/m^3 for 166 minutes.

   b. Percutaneous. 10,000 mg min/m^3.

9. Median Lethal Dosage, Animal:

   a. Inhalation. (LCt_{50}'s).

Dichloroethylarsine

(1) Mice. 3400 mg min/m^3 (t = 10).

(2) Dog. 2700 mg min/m^3 (t = 30), and 4800 mg min/m^3 (t = 120).

(3) Cat. 800-8000 mg min/m^3 (t = 40). "Fatal" after a few days.

(4) Guinea Pig. $\leq$3000 mg min/m^3 (t = 30).

b. Percutaneous.

(1) Vapor (body exposed, head protected).

Species	LCt_{50} (Estimated)	Exposure Time
	mg min/m^3	min
Mouse	12,500	10-15
Rat	23,000	15-20
Guinea Pig	33,000	15
Rabbit	15,000	10-20
Cat	25,000-30,000	10-20
Dog	500,000	20-120

(2) Liquid (LD_{50}'s).

Rabbit. 8 mg/kg.

Guinea Pig. 20 mg/kg.

c. I.P. Injection.

Dog. An injection of 1 mg/kg is fatal.

10. Median Incapacitating Dosage, Man:

Inhalation. Median "temporary" incapacitation dosage: 5-10 mg min/m^3 (TM 3-215).

11. Threshold Limit Value: No data.

12. Minimum Effective Dosage, Man:

Threshold concentrations, nasal irritation: 46-412 mg/m^3, osmoscope tests in 19 subjects.

13. & 14. Physiological Effects (Acute and Chronic):

ED is a semipersistent vesicant compound of fairly rapid action. It also produces systemic arsenical poisoning when applied to the skin. It is similar but inferior to lewisite in its vesicant action. A typical burn from liquid ED (0.005 ml on 5 cm^2) on dog's skin produces immediate hyperemia; marked swelling which is sharply localized during the early stages; a zone of marginal anemia about the area of application; petechial hemorrhage with discoloration; edema with extension of the swelling, necrosis and ultimately dry gangrene; ulceration and eventually healing, which is completed in 26 to 38 days.

The vapors of ED are strongly irritant to the nose and throat. Irritation is apparent before its faint fruity odor is perceived. The particular effects of ED on man are described as sharp irritation of the upper respiratory tract (sneezing, tickling in throat and trachea, coughing), headache, nausea, faintness, chest congestion, and painful oppression.

From experiments on animals, ED appears to have a high toxicity by inhalation. Its lethal action is that of a bronchial and lung irritant. The effect of the gas on inhalation is essentially that of immediate, local irritation of the exposed parts of the eyes, and upper and lower respiratory tracts. Besides the local irritating effects, animals whose bodies are exposed to vapors of ED develop systemic effects as evidenced by subnormal temperature, ataxia and depression. Dogs exposed to 40 mg/m^3 for 30 minutes excrete arsenic in the urine, between 0.15 and 0.2 mg on the second day following exposure.

Prolonged exposure of man to low concentrations may produce numbness of the fingers, neuritis, and eventual paralysis. Bronchitis and pneumonia are common sequelae. Pain under the fingernails is frequent.

15. Onset Time of Symptoms:

No particular onset times of specific symptoms could be found. World War II data indicate that ED is "comparable" to Lewisite but inferior to it as a casualty agent.

Dichloroethylarsine

16. Self Aid and First Aid:

See Item 16 for Chemical Agent HD. Immediate decontamination is required to remove the liquid agent to prevent severe burns. Severe exposure of the eyes may cause permanent injury or blindness. Systemic use of morphine and local and systemic use of antibiotics may be necessary along with frequent flushing with 1% saline solution. Dimercaprol (BAL) ointment should be applied to the skin for local neutralization. Intramuscular injection of BAL in oil may be given for systemic poisoning. Dosage is adjusted to the weight and severity of the case (see TM 8-285 paragraph 43). In toxic patients, liberal fluids by mouth, or by IV's and high vitamin, high protein diets are necessary. In cases of shock, the usual supportive measures are required.

17. Tolerable Environmental Concentration to Uncontrolled Populations:

No data.

18. Molecular Weight: 174.9

19. Purity Range:

a. Laboratory Sample: 95 to 99%.

b. Plant Sample:

20. Physical Appearance: Clear, somewhat oily liquid.

21. Vapor Density, Relative to Air: 6.5.

22. Liquid Density: 1.66 g/ml @ 20° C.

23. Solid Density:

a. Bulk Density. Not applicable.

b. Crystal Density. Not applicable.

24. Normal Freezing Point or Melting Point: Less than -65° C.

25. Boiling Point: 156° C.

26. Vapor Pressure: 2.09 mm Hg @ 20° C.

27. Volatility: 2×10^4 mg/m^3 @ 20° C.

28. Viscosity: Unknown.

29. Flash Point: High enough not to affect military use.

30. Autoignition Temperature: Unknown.

31. Latent Heat of Vaporization: 52.5 cal/g.

32. Latent Heat of Fusion: Not available.

33. Vapor-Air Explosive Hazard Range: Not available.

34. Relative Persistency: Nonpersistent.

35. Solubility (g/100 g solvent):

    a. Water (distilled). Slightly soluble, hydrolyzes.

    b. Other. Ethanol, chloroethane, acetone, benzene, cyclohexane.

    c. Best Solvent. Organic solvents.

36. Thermal Decomposition Rate: Stable to boiling point.

37. Heat of Combustion: Unknown.

38. Products of Combustion: May produce C_2H_5AsO (toxic).

39. Rate of Hydrolysis: Rapid.

40. Hydrolysis Products: HCl + C_2H_5AsO (ethylarsenious oxide).

41. Corrosive Properties:

Does not attack iron up to 50° C when pure; attacks brass, rubber and plastic. Does not attack steel when pure.

42. Detection Methods and Equipment:

For Liquid: ABC-M8 detector paper; M6A1 detector paper.
For Vapor: M18A2, M19 kits (yellow band tube); Molybdenum Blue Test.

43. Decontaminants:

a. Personnel. Flush eyes with uncontaminated H_2O. Skin pad from M13 kit; M5 protective ointment. M13 kit for clothing.

b. Equipment. DANC, bleach, caustic soda, or DS2 in closed spaces.

c. Areas. Aeration. Terrain: STB slurry applied by M9 or M12A1 decontaminating apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilized: Stable when dry.

46. Types of Containers Required for Storage:

a. RDT&E Quantities. Glass.

b. Stockpile Quantities. Stable in steel containers for 1 year at ambient temperature. Attacks brass at 50° C; destructive to rubber and plastics.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: Unknown.

1. Chemical Code or EA Number: H

2. Chemical Name: Levinstein Mustard. Composed of about 70% Bis (2-chloroethyl) sulfide and 30% of usually higher MW polysulfides.

3. Chemical Formulae:

   a. Empirical.

   b. Structural.

4 - 17. Most Levinstein H consists of about 70% pure H with about 30% of polysulfides. The percent of pure H in Levinstein H varies from sample to sample and therefore no specific data can be given on its colligative properties.

The biological properties of H are similar to those given for HD (q.v.).

18. Molecular Weight: Average MW varies with purity, but is generally higher than that of pure mustard (159.08).

19. Purity Range (average):

   a. Laboratory Sample.

   b. Plant Sample. 64 to 69 wt%.

20. Physical Appearance: Amber to dark brown liquid.

21. Vapor Density, Relative to Air: Varies with MW, generally exceeds value for HD of 5.5.

22. Liquid Density: 1.27 g/ml @ 25° C; fairly constant, independent of product purity.

23. Solid Density:

   a. Bulk Density. Not applicable.

   b. Crystal Density. Not applicable.

Levinstein Mustard

24. Normal Freezing Point or Melting Point: approx. 8° C.

25. Boiling Point: Varies with product composition; decomposes around 180° C.

26. Vapor Pressure :

    No general value since vapor pressure varies with purity of sample. High molecular weight impurities of H tend to lower vapor pressure below 0.11 torr reported for HD.

27. Volatility: approx. 920 mg/m^3 @ 25° C (reported for HD).

28. Viscosity: See HD.

29. Flash Point: 105° C.

30. Autoignition Temperature: Unknown.

31. Latent Heat of Vaporization: In the range of 94 cal/g reported for HD.

32. Latent Heat of Fusion: See HD.

33. Vapor-Air-Explosive Hazard Range: Not available.

34. Relative Persistency:

    a. Soil. Persistent.

    b. Surface (Wood, Methal, Masonry, Rubber, Paint).

    c. Water. Persistent due to low solubility.

35. Solubility: Similar to HD.

36. Thermal Decomposition Rate (half-life): See HD.

37. Heat of Combustion: 4500 cal/g (calculated from bomb calorimetry for products given in Item 38).

38. Products of Combustion: CO_2, Cl_2, H_2O, H_2SO_4, HCl (bomb calorimetry).

39. Rate of Hydrolysis: See HD.

40. Hydrolysis Products: See IID.

41. Corrosive Properties: Brass rapidly corroded; cast iron poor.

42. Detection Methods and Equipment:

Spotted Disk (SD) Test, Dragendorff Test.

For Liquid: ABCM8 detector paper; M6A1 detector paper.
For Vapor: M15A2, M18A2, M19 kits
(DB-3 Test, blue band detector tube)

43. Decontaminants:

a. Personnel. Flush eyes with H_2O. Protective ointment M1, M5 ointment; M13 kit (liquid on skin). M13 Kit - outer clothing. Shower with soap and water.

b. Equipment. Bleaching powder, DANC, DS2, sodium hypochlorite, fire.

c. Areas. Terrain: Aeration. STB slurry applied by M9 or M12A1 decontaminating apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilize :

a. Laboratory Sample. See IID.

b. Production Sample.

46. Types of Containers Required for Storage:

a. RDT&E Quantities. Glass.

b. Stockpile Quantities. One-ton containers, 55-gallon steel drums, steel cylinders.

47. Q-D Classification: 8
Compatability Group: A
Chemical Group: A

Next page is blank.

1. Chemical Code or EA Number: HD

2. Chemical Name: Bis (2-chloroethyl) sulfide, Distilled Mustard.

3. Chemical Formulae:

   a. Empirical. $C_4H_8Cl_2S$

   b. Structural. $ClCH_2CH_2SCH_2CH_2Cl$

4. Biological Type Compound: Lethal agent.

5. Principal Pharmacological Action:

HD is a vesicant. Besides cutaneous vesication, it produces eye injuries and damage to the respiratory tract. It is also an alkylating agent having the ability to react with a wide variety of compounds found in various tissues of the body thus producing a cytotoxic action. The hematopoietic tissues (blood-cell forming) such as bone marrow, lymph nodes, and spleen are especially sensitive. Its rate of detoxification is very low. Very small repeated exposures are cumulative due to sensitization.

6. Characteristic Odor: Garlic-like.

7. Effective Routes of Administration.

   Ocular, percutaneous, inhalation, ingestion, injection.

8. Median Lethal Dosage, Man:

   a. Inhalation (unprotected men). LCt_{50}, 1,500 mg min/m^3. Since the effects of HD are cumulative, the Ct given is not significantly changed with variations in time of exposure within reasonable limits.

   b. Percutaneous.

      (1) Vapor: (masked personnel), LCt_{50}, 10,000 mg min/m^3.

      (2) Liquid: LD_{50} has been estimated at 7.0 g/70 kg man.

c. Ingestion. No data on the LD_{50} by this route. An inebriated man with suicidal intent drank 5 ml (6.4 grams) and died within 5 hours despite treatment.

9. Median Lethal Dosage, Animal:

a. Inhalation.

Species	t	LCt_{50}
	min	mg min/m^3
Mouse	2	860
	10	1,200
	10	1,200
	60	1,380
Rat	2	840
	10	800
	10	850
	60	900
	360	1,512
Guinea Pig	10	1,700
Rabbit	10	900 (nominal concn)
	ca 30	1,025
Cat	10	700 (nominal concn)
Dog	10	600 (nominal concn)
Goat	10	1,900
Monkey	10	800 (nominal concn)

b. Percutaneous.

(1) Vapor (body exposure).

Species	t	LCt_{50}
	min	mg min/m^3
Mouse	10	3,400
Rat	10-20	ca 3,000
Guinea Pig	80	ca 20,000
Rabbit	18-32	5,000
Cat	30-78	8,700
Dog	60	7,700
Monkey	45-100	13,000

(2) Liquid, Approximate LD_{50}'s

	mg/kg
Mouse	92
Rat	18
Rabbit	100

c. Intravenous.

Species	LD_{50}'s mg/kg	Solvent
Mouse	8.6	PG (Propylene glycol)
	3.3	Neat
Rabbit	2.7	PG
	ca 1.1	TG (Thiodiglycol)
	3.6	Neat, rapid inj.
	4.5	Neat, slow inj.
Dog	0.2	TG

Distilled Mustard

d. Subcutaneous.

Species	LD_{50}'s mg/kg	Solvent
Mouse	26	PG
	30	Neat
	20-30	Tributyrin
Rat	2-5	Tributyrin
	5.2	Neat
Rabbit	20-30	Tributyrin
Goat	40	Neat

e. Intragastric.

Rat: LD_{50}, 17.0 mg/kg

10. Median Incapacitating Dosage, Man (ICt_{50}'s):

a. Inhalation. No data.

b. Percutaneous (Masked Personnel). 2000 mg min/m^3 at environmental temperatures of 70-80° F. Wet skin absorbs more mustard than dry skin; therefore, mustard exerts a casualty effect at lower concentrations in hot humid weather since the skin is then moist with perspiration. Above 80° F, perspiration causes increased skin absorption. The incapacitating dosage drops rapidly as perspiration increases; at 90° F, 1000 mg min/m^3 could be incapacitating.

c. Eyes. 200 mg min/m^3.

11. Threshold Limit Value: No data.

a. Maximum Allowable Ct for Skin. 5 mg min/m^3.

b. Maximum Allowable Ct for Eyes. 2 mg min/m^3.

12. Minimum Effective Dosage, Man:

a. Skin. Mild to moderate erythema develops at Ct's of 50 mg min/m^3 at temperatures of 90° F.

b. Eyes. Marginal eye effects: 12-70 mg min/m^3. Mild reddening of eyes, no incapacitation: 70 mg min/m^3. Marginal incapacitation: 90 mg min/m^3.

13 & 14. Acute Physiological Effects and Onset Time of Symptoms:

a. Eyes (Acute Exposure).

Vapor. The eye is more sensitive to the action of HD than any other part of the body. Exposure for 2 hours to a concentration of HD barely perceptible by odor will produce eye lesions but may not affect the respiratory system or skin. There is no immediate symptomatic or local reaction to the absorbed agent. A latent period that varies with the degree of exposure precedes the onset of symptoms.

Mild exposure and onset time of symptoms.

The latent period after a mild exposure varies from 4 to 12 hours. The symptoms are: lacrimation and a sensation of "sand" in the eyes. The conjunctiva and lids become swollen and edematous. Recovery is usually within 1 or 2 weeks.

Moderate exposure and onset time of symptoms.

The onset time for a moderate exposure is 3-6 hours after exposure. The symptoms are blepharospasm and blurring of vision, marked hyperemia and edema of the conjunctiva with a prominent interpalpebral band, edema of lids, mold iritis, and edema of the epithelium of the cornea which produces a roughened appearance like that of orange peel. Miosis occurs early. A mucoserous discharge is usually present which may cause the lids to stick together resulting in an accumulation of secretions in the conjunctival sac and predisposition to infection. The recovery period is usually 1-6 weeks.

Severe exposure and onset time of symptoms.

After a latent period of 1-3 hours there is deep ocular pain and headache, severe blepharospasm, blurred or dimmed vision, marked hyperemia and edema of the conjunctiva with necrosis. If the damage is progressive there may be dense corneal opacification with deep ulceration and vascularization. Convalescence is usually several months.

Liquid. Droplets of liquid HD may produce signs and symptoms similar to the severe effects of the vapor mentioned above.

b. Skin (Acute Exposure).

(1) Local Effects (Vapor).

The effectiveness of H vapor as a skin injurant varies markedly with the degree of skin wetness which depends not only on air temperature but also on relative humidity and physical activity. Even under temperate conditions, the warm moist skin of the perineum, external genitalia, arm pits, antecubital fossae, and neck are particularly susceptible.

HD is insidious in that immediate symptoms do not accompany the exposure, nor do any local manifestations occur until erythema (reddening of the skin) develops.

This latent period varies with the degree of exposure. It may be as short as an hour after liquid contamination when the weather is hot and humid or as long as several days after mild vapor exposures. With most vapor exposures in temperate weather, the latent period is usually 6 to 12 hours.

The first sign is erythema which appears gradually and becomes brighter resembling sunburn. There may be itching and mild burning at this stage. It may last several days and persist after healing. Except for mild vapor burns the erythema is followed by blistering. Pinpoint lesions may arise within the erythematous skin; these enlarge and coalesce to form the typical large, domed, thin walled, translucent, yellowish blister surrounded by erythema. The blister fluid is clear at first, thin and straw colored, later yellowish and tending to coagulate. It is completely non-irritating. If the blister does not rupture resorption takes place in about a week.

(2) Systemic Effects (Vapor).

Severe systemic effects due to blister agents probably will be encountered only with disabling skin lesions. The signs and symptoms inlcude anorexia, nausea, vomiting, depression, and fever, and are far more prone to occur in hot than in temperate climates. Malaise and nausea generally are the first reactions, and may then progress either to mild, transient vomiting or to severe, persistent

vomiting and retching. Anorexia may be the only complaint in mild reactions. The actual time of onset of symptoms is 4 to 12 hours after exposure, and symptoms often occur before skin injury is manifest. No rule can be given for the duration of systemic symptoms, although men usually have recovered from severe vomiting within 24 to 36 hours. Anorexia and nausea may persist for a longer time.

The temperature may remain elevated for several days. Mental depression may follow mustard burns and persist also for several days.

Men with systemic reactions will generally be casualties, particularly in view of the probability of associated extensive skin burns. Such cases should be evacuated quickly.

c. Respiratory Tract.

Respiratory tract lesions develop slowly and do not reach maximal severity for several days. Symptoms begin with hoarseness, which may progress to aphonia. A cough, worse at night, appears early and later becomes productive. Fever, dyspnea, and moist rales may develop. The incidence of bronchopneumonia is high. Convalescence is slow and cough may persist a month or longer. Milder symptoms, like hoarseness, last only 1 or 2 weeks.

d. Gastrointestinal Tract.

Ingestion of food or water contaminated by liquid mustard produces nausea and vomiting, pain, diarrhea, and prostration. Mustard vapor does not significantly contaminate food or water.

15. Chronic Physiological Effects and Onset Time of Symptoms:

a. Eyes, Chronic Exposure.

One hundred and seventeen factory workers handling mustard were questioned with regard to subjective eye symptoms and their eyes examined externally for conjunctival infection and corneal sensitivity, stained with fluorescein and examined with the slit lamp. The length

of time the subjects worked at the mustard plant ranged from 1 month to 15 months or longer.

Although no serious eye condition was found among the workers, the objective findings were: low grade conjunctival infection, reduced corneal sensitivity, superficial punctate staining of the corneal epithelium, and pigmentation of the corneal epithelium. Employees who had worked 1-2 months showed no corneal change.

The percentage of workers showing corneal change and length of time they had worked in the mustard plant are shown below.

Months	No. of Subjects	% showing corneal change
1-2	5	0
3-4	10	50
5-6	9	33
7-8	5	40
9-10	19	90
11-12	19	84
13-14	13	92
15 or longer	37	65

b. Skin.

(1) Acute Exposure.

Mustard burns of the skin are usually followed by a persistent brown pigmentation except at the site of actual vesication where there may be depigmentation.

(2) Chronic Exposure.

Repeated burns may lead to hypersensitivity of the skin to mustard. Sensitization will be followed by a more rapid onset of symptoms upon re-exposure. Erythema with or without edema and pronounced itching and burning usually appear within 1 hour. Lower concentrations of HD are required to produce effects in a sensitized man. When erythema and edema result from exposure to a low dose they generally develop rapidly and subside within 2 to 3 days. Also vesication heals more rapidly in the sensitized man.

One of the most frequent manifestations of re-exposure in sensitized men is the development of a morbilliform rash. Another characteristic reaction is the appearance of eczematoid dermatitis surrounding old lesions, whether or not they are healed. This may last for several days and resembles dermatitis venenata (from poison ivy). Similar phenomena due to sensitization have been known to occur with lewisite and with the nitrogen mustards.

16. Self Aid and First Aid.

Wear the protective mask, hood, and clothing whenever liquid or vaporized vesicant agents are known to be present.

Liquid vesicants in the eyes or on the skin require immediate decontamination procedures as outlined below.

Following contamination of the skin, clothing, or eyes, personal decontamination must be carried out immediately, since there is a definite time limit after which decontamination is useless. Decontamination consists of either removal or neutralization of the agent, or both, before serious injury occurs. Each man will decontaminate himself unless he is incapacitated. If an individual cannot decontaminate himself, the man nearest should assist him if the situation permits. If conditions at the time of exposure compel uninterrupted performance of tasks, the protective mask should be put on and personal decontamination accomplished as soon as possible.

a. Eyes.

When the eyes are contaminated, the agent must be removed instantly. If an individual suspects contamination of his eyes or face, he must immediately obtain overhead shelter to protect him while the following decontamination process is performed:

(1) Remove and open canteen.

(2) Prepare skin pad from M13 kit.

(3) Take a deep breath and hold it.

(4) Remove the mask.

(5) Flush or irrigate the eye, or eyes, immediately with water. To flush an eye with water from a canteen, or other container of uncontaminated water, tilt the head to the side, pull the eyelids apart with the fingers, and pour water slowly into the eye so that it will run off the side of the face to avoid spread of the contamination. This irrigation must be carried out despite the presence of toxic vapors in the atmosphere. The breath should be held as long as possible

and the mouth kept closed during this procedure to prevent contamination and absorption through mucous membranes. The risk of leaving HD in the eye is so much greater than that from exposure to vapors, during the short period of decontamination, that decontamination must be performed.

(6) Use skin pad to decontaminate both the face and the portion of the mask which came into contact with the contamination on the face.

(7) Replace mask and resume breathing.

(8) Never use M5 Protective Ointment or components of the M13 kit in or around the eyes, as they are extremely irritating to the eyes. The decontamination process should be repeated as necessary until the individual is sure that the decontamination of his eyes or face is complete.

b. Skin and Clothing.

The M13 individual decontaminating and reimpregnating kit is provided as an emergency means of either decontaminating the individual's skin and outer clothing when subjected to contamination by chemical agent or as a means of reimpregnating his protective liner outfit (liner shirt and trousers, gloves, and socks). Disposable outer garments are removed and discarded if they become contaminated by agent.

Note the following safety precaution:

Caution: Do not attempt to decontaminate the face or eyes before donning a protective mask.

(1) Don a protective mask and protective gloves before using the M13 individual decontaminating and reimpregnating kit.

(2) Decontaminate exposed skin areas other than the face immediately after masking.

(3) Use the buddy system to decontaminate the skin and clothing areas that cannot be reached or seen by the individual on his own person.

(4) Remove and discard disposable outer garments if they become contaminated by splashes of agent.

(5) Remove and discard the outer layer of the uniform if it is heavily contaminated with wet spots or streaks of agent.

(6) Remove excess powder from clothing and equipment. Before removing the mask, check the surrounding atmosphere with a detector kit (FM 21-41).

(7) Remove contaminated outer garments before entering a shelter.

c. Use of M13 Kit.

(1) Description. The M13 individual decontaminating and reimpregnating kit measures approximately 1-7/8 by 2-7/8 by 1-1/8 inches and weighs approximately 0.7 pound. A plastic bag containing two cloth bags each filled with decontaminating and reimpregnating powder and a capsule containg a dye, a cutter, and a plastic packet containing a pad filled with skin decontaminating powder are packed in a plastic or metal case.

(a) Case. The case is made of either metal or plastic and is closed with a friction-fit cover equipped with a puller handle.

(b) Cloth bags. The cloth bags are made of knit material. Each bag contains decontaminating and reimpregnating powder and a crushable plastic capsule filled with a chemical agent detector dye. The dye produces a red or brown color when it comes in contact with liquid agent. The capsule containing the chemical agent detector dye is crushed and mixed with the powder just prior to use for decontaminating. The dye capsule is not crushed when the bag is used for reimpregnating.

(c) Cutter. The cutter is a single-edged cutting device encased in a plastic safety sheath. It is used to cut away heavily contaminated (red or brown spots) areas of clothing. It is packed in a pouch on the outside of the plastic bag.

(d) Skin decontaminating pad. The skin decontaminating pad is a continuous belt-type pad designed to fit over the gloved fingers. The exterior surface of the pad is woven cloth and the interior surface is plastic. The pad, which is filled with an absorbing powder, is used to blot and absorb liquid chemical agent from exposed skin surfaces.

(2) Instructions for Decontaminating in Temperate Climate:

Warning: Observe the safety precautions as stated. Don protective mask and gloves. Remove the M13 kit from the carrier pocket. Push up on the bottom of the pocket and lift the can out of the pocket. Grasp the puller handle and remove the cover. Follow the procedure given below.

Distilled Mustard

(a) Decontaminating skin.

Remove the plastic packet from the case and tear it open. Remove the skin decontaminating pad from the packet and unfold it. Fit the pad over the fingers.

Using the portion of the pad on the back of the hand, blot all visible spots on the exposed skin.

Using the portion of the pad on the palm of the hand, powder the exposed skin (including skin folds) and rub the powder over the skin surface.

(b) Decontaminating clothing.

Remove the plastic bag from the case. Open the bag and remove one of the cloth bags. Locate the capsule inside the bag with the fingers and crush the capsule between the fingers or palms of the hands. Knead the bag with the fingers for approximately 1 minute to thoroughly mix the dye with the powder. Use the full contents of one bag to decontaminate the clothing.

Dust all outside surfaces of the gloves with powder from the cloth bag and lightly rub the powder into the gloves with the bag.

Dust the outer clothing with the cloth bag and rub the powder lightly into the clothing. Inspect while dusting and rubbing for red or brown spots which indicate areas heavily contaminated with liquid agent. If a large number of widely scattered colored spots appears, do not attempt to further decontaminate the clothing. Remove and discard the clothing as quickly as possible.

If a few spots appear in a small area--remove the cutter from the outside pocket of the plastic bag. Holding the cutter with one hand, grasp and pull the spotted area of clothing away from the body with the other hand. With a sawing motion, cut away spotted areas. Be especially careful to remove those areas which are in close contact with the waist, knees, elbows, shoulders, groin, crotch, and seat. Cut away and discard the cutout material as quickly as possible.

Dust either the underwear or the protective liner outfit (whichever is worn) with powder through the holes that have been cut in the outer clothing. If colored spots appear on the protective liner outfit or on the underwear, cut out the spotted areas and throw them away. Using the skin decontaminating pad, dust the exposed skin through the holes in the underwear or protective liner outfit.

As soon as the tactical situation permits brush or beat the clothing with the gloved hands to restore camouflage.

(3) Decontaminating in arctic climate.

Decontaminate as described in (2) above (temperate climate) but omit the cutting away of colored spots because the thickness and number of layers of clothing will prevent liquid agent from coming in contact with the skin beneath the clothing.

(4) Decontaminating in tropical or desert climate

Decontaminate as described in (2) above. In addition, apply decontaminating powder from the cloth bag over all bare skin areas. This will help to protect bare skin areas from agent vapors.

d. Use of Protection and Treatment Set (M5).

If the M13 kit is not available, the M5 protection and treatment set may be used for personal decontamination. If any liquid contamination gets on the skin, it must be removed promptly. The liquid on the skin should be pinch-blotted with cloth available in the protection and treatment set. The blotting should be done with as little rubbing as possible, because rubbing spreads the contamination and increases the absorption of a nerve agent. The contaminated area then should be flushed with water and M5 Protective Ointment applied freely to the contaminated skin, rubbed in and the excess ointment wiped off. A second application of the ointment should be made and allowed to remain on the skin as a visible film. Contaminated clothing, including shoes, should be quickly removed, or cut away if removal is impossible and clothing decontaminated or discarded. Areas underneath contaminated clothing should be decontaminated. Under no circumstances should contamination be carried by personnel into inclosed spaces.

17. Tolerable Environmental Concentrations to Uncontrolled Population:

No data.

18. Molecular Weight: 159.08.

19. Purity Range:

a. Laboratory Sample. 95 to 100%.

b. Plant Sample.

20. Physical Appearance: Pale yellow liquid.

Distilled Mustard

21. Vapor Density, Relative to Air: 5.5

22. Liquid Density: 1.27 g/ml @ 25° C.

23. Solid Density:

a. Bulk Density (g/cm^3). Not applicable.

b. Crystal Density: 1.37 g/cm^3 @ 0° C.

24. Normal Freezing Point or Melting Point: 14.45° C.

25. Boiling Point: 217° C extrapolated.

26. Vapor Pressure: 0.11 mm Hg @ 25° C.

27. Volatility: 920 mg/m^3 @ 25° C.

28. Viscosity: 3.95 centistokes @ 25° C.

29. Flash Point: 105° C. Low enough to cause occasional ignition if explosive charges in the shell are too great.

30. Autoignition Temperature: Unknown.

31. Latent Heat of Vaporization: 94 cal/g.

32. Latent Heat of Fusion: 26.5 cal/g.

33. Vapor-Air Explosive Hazard Range: Unkown.

34. Relative Persistency:

a. Soil.

Depends on type of soil, pH and moisture content. H sprayed on soil vesicant for about 2 weeks. H that had leaked into soil was still vesicant after 3 years.

b. Surface (Wood, Metal, Masonry, Rubber, Paint). Permeates ordinary rubber.

c. Water. Approximately one hour @ 25° C, one of decomposition products as toxic as H. Compound about twice as persistent in seawater.

35. Solubility (g/100 g solvent):

a. Water (distilled). 0.092 at 22° C.

b. Other. Completely soluble in acetone, CCl_4, CH_3Cl, tetrachloroethane, ethyl benzoate, ether. Completely soluble in 92.5% ethanol above 28.6° C.

c Best Solvent. Organic solvents.

36. Thermal Decomposition Rate: Decomposes at temperatures 149° - 177° C.

37. Heat of Combustion: -756.03±0.15 kcal/mole (determined by using 99.5% pure mustard).

38. Products of Combustion: CO_2, HCl, Cl_2, H_2O, H_2SO_4 (bomb calorimetry).

39. Rate of Hydrolysis (half-life):

a. Acidic (pH). 5 min @ 22° C; pH unknown.

b. Basic (pH). Unknown.

40. Hydrolysis Products:

a. Acidic. Thiodiglycol - $(HOCH_2CH_2)_2S$ and HCl

b. Basic.

$$(HOCH_2CH_2)_2S + Cl^-$$

41. Corrosive Properties: Brass rapidly corroded at 65° C.
0.0001 inches/month at 65° C on steel

42. Detection Methods and Equipment:

a. Liquid. 1 g/ml of solution with DB3 & sodium tetrachloromercurate (colorimetric). ABC-M8 detector paper.

b. Vapor. 3×10^{-3} g (to detector with gas chromatography). M15A2 and M18A2 kits.

43. Decontaminants:

a. Personnel. Flush yes w/H_2O. Protective ointment M1, M5 ointment; M13 kit (liquid on skin). M13 kit - outer clothing. Shower with soap and water.

b. Equipment. Bleaching powder, DANC, DS2, sodium hypochlorite, fire.

c. Areas. Terrain: Aeration. STB slurry applied by M9 or M12A1 decontaminating apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

a. Laboratory Sample. Can be stabilized with acridine or naphthoquinoline.

b. Production Sample.

46. Types of Containers Required for Storage:

a. RDT&E Quantities. Glass.

b. Stockpile Quantities. One-ton steel containers.

47. Q-D Classification: 3
Compatiblity Group: A
Chemical Group: A

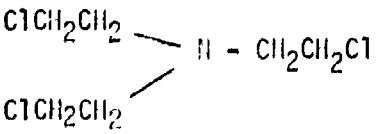
1. Chemical Code or EA Number: HN-3

2. Chemical Name: 2, 2', 2" - Trichlorotriethylamine, Nitrogen Mustard -3.

3. Chemical Formulae:

   a. Empirical. $C_6H_{12}Cl_3N$

   b. Structural.



4. Biological Type Compound: Lethal agent.

5. Principal Pharmacological Action:

HN-3 is a vesicant, and similar to HD, produces eye injury, damage to the respiratory tract and, after absorption into the body, produces cytotoxic actions in a variety of tissues. The hematopoietic and lymphoid tissues are especially sensitive. These cytotoxic effects follow absorption through the intact skin, respiratory or gastrointestinal tracts.

6. Characteristic Odor: None when pure.

7. Effective Routes of Administration: Ocular, percutaneous, inhalation, ingestion, injection.

8. Median Lethal Dosage, Man:

a. Total Exposure (Head and Body Unprotected). LCt_{50}, 1500 mg min/m^3.

Since HN-3 is not detoxified and the effects are cumulative, this Ct is not significantly changed with variations in time of exposure within reasonable limits.

b. Percutaneous.

Vapor, LCt_{50}, masked personnel. 10,000 mg min/m^3.

Liquid, approximate LD_{50}. Estimated to be 0.7 g/70 kg man.

Nitrogen Mustard

9. Median Lethal Dosage, Animal:

a. Total Exposure (Head and Body Unprotected).

(Temperatures given when known).

Species	LCt_{50}*	t	Remarks
	(mg min/m^3)	(min)	
Mouse	165	10	Vapor, wind tunnel, 5.5 mph, 95° F
	345	10	Aerosol (2 μ), wind tunnel, 5.5 mph, 80° F
	500-600	10	Aerosol-free vapor
	590	10	Low-flow chamber
	300	10	High flow chamber, aerosol present
Rat	ca 800	0.25-2	Fine aerosol
	1700 (N)**	10	Low-flow chamber
	670	10-100	Vapor, 90° F, 85% R.H.
Guinea Pig	2300 (N)**	10	Low-flow chamber
	1000	30	Static chamber, 80° F
Rabbit	ca 585	3-15	Vapor, wind tunnel, 5.5 mph, 95° F
	830	18-50	Low-flow, 72° F
	500	10-18	Low-flow chamber, vapor only, 100° F
	635	10-100	Vapor, 90° F, 85% R.H.
Cat	400-1000	10	Low-flow chamber
Dog	400-1500	10	Low-flow chamber
Goat	500-1000	30	Static chamber, 85° F

* Analytical concentration unless otherwise stated
** Nominal concentration

b. Inhalation (Head Exposed, Body Protected).

Species	LCt_{50} (mg min/m^3)	t (min)	Remarks
Mouse	1100	10	Low flow
	1200	10	High flow
Rabbit	650	10	Vapor, wind tunnel, 5.5 mph, 95° F
	1000	10	Vapor, low flow, 72° F
	600-800	10	Vapor, low flow, 100° F

c. Percutaneous.

(1) Vapor (body exposed, head protected).

The percutaneous toxicities of HN-3 vapor for all animal species except the mouse were found to be insignificant when compared with total exposure toxicities. In the mouse, HN-3 was more toxic by body exposure than by inhalation.

Mouse LCt_{50}'s (mg min/m^3), t = 10 min

Types of Exposures			Flow
Body (PC)	Inhalation	Total	
1000	1100	590	Low
370	1200	300	High

(2) Liquid, LD_{50}'s in mg/kg.

Mouse - 7.0 (base)
Rat - 4.9 (base)
Rabbit - 19.0 (base)
Dog - 10.0 (base)
Goat - 20.0 (base)

d. Intravenous, LD_{50}'s in mg/kg.

Mouse	1-2
Rat	0.7 (HCl)
Rabbit	2.5 (HCl)
Dog	1.0

e. Subcutaneous, LD_{50}'s in mg/kg.

Mouse	2.0 (HCl)
Rat	2.0 (HCl)
Guinea Pig	7-10
Rabbit	2.0 (base)
Goat	20-30 (base)

f. Intragastric, LD_{50}'s in mg/kg.

Rat 2.5 mg/kg (HN-3 in corn oil)

10. Median Incapacitating Dosage, Man (ICt_{50}'s):

a. Inhalation. No data.

b. Percutaneous (Masked Personnel). 2500 mg min/m^3.

c. Eye Injury. 200 mg min/m^3.

11. Threshold Limit Value. No data.

12. Minimum Effective Dosage: No data on minimum effective dosage. Effects of low dosages for man are given below.

a. Eyes. Although exposure to an HN-3 vapor dosage of 20 mg min/m^3 (t unknown) produced no subjective symptoms among four volunteers, all showed moderate conjunctival infection. Grossly, their corneas seemed normal, but slit-lamp examination revealed moderate to marked epithelial edema. Three volunteers exposed to 42 mg min/m^3 (t = 7 min) developed lacrimation, photophobia, and a gritty feeling in the eye. Grossly, their corneas were normal and did not stain with fluorescein, but slip-lamp examination revealed epithelial edema and slight infiltration of the anterior stroma. One developed moderate edema of the lids. On the fourth day after exposure, all were improving both subjectively and objectively.

b. Skin. Median threshold blistering dosage, ca. 70 mmg.

13. & 14. Acute Physiological Effects and Onset Time of Symptoms:

a. Eyes.

In single exposures, nitrogen mustards irritate the eye in doses which do not significantly damage the skin or respiratory tract. This irritation appears sooner than that from mustard.

Mild or moderate exposure causes slight smarting and lacrimation within 20 minutes. Thereafter, symptoms may wax and wane until they become persistent about 2-1/2 hours later and reach their maximum in 8 to 10 hours. Mild exposure produces erythema and edema of the palpebral and bulbar conjunctivae and superficial, steamy haziness of the cornea. Irritation, lacrimation, deep eye pain, miosis, and photophobia are usually present.

After more severe exposure, symptoms begin immediately and progress for 24 hours or longer. These symptoms are followed by spotty hemorrhagic discolorations of the iris. The corneal epithelium shows a roughened, lusterless surface, with areas of punctate staining (fluorescein). Severe exposure may cause the corneal epithelium to exfoliate. Slit lamp examinations will reveal clouding and edema of the corneal substance extending deep below the Bowman's membrane. Local necrosis of the cornea may rupture the globe.

b. Skin.

In mild vapor exposures, there may be no skin lesions. After severe vapor exposure or after exposure to liquid nitrogen mustard, erythema may appear earlier than in mustard contamination. There may be irritation and itching as with mustard. Later, blisters may appear in the erythematous areas. The skin lesions are similar to those caused by mustard.

c. Respiratory Tract.

The symptoms are the same as those caused by mustard, namely, delay in appearance, irritation of the nose and throat, hoarseness progressing to aphonia, and a persistent cough. Fever, dyspnea, and moist rales may develop. Bronchopneumonia may appear after the first 24 hours.

Mild tracheitis may result in a persistent cough. Low grade fever may persist a week or longer. The prognosis is grave if there is a severe respiratory tract involvement. Late deaths due to pneumonia may occur.

d. Gastrointestinal Tract.

Following oral administration or systemic absorption, the nitrogen mustards injure the intestinal tract. In animals severe diarrhea, which may be hemorrhagic, occurs. Lesions are most marked in the small intestine and consist of degenerative changes and necrosis in the mucosa. In man the ingestion of 2 to 6 milligrams causes nausea and vomiting.

e. Systemic Effects.

The most specific effects of the nitrogen mustards are on the hematopoietic and lymphoid tissues. These effects follow absorption from the intact skin, respiratory or gastrointestinal tract. In bone marrow the degenerative changes can be detected within 12 hours and may progress to severe aplasia. The thymus, spleen, and lymph nodes involute rapidly, with necrosis and phagocytosis of their lymphocytes. This injury is demonstrable in the blood as a transient leucocytosis of a few hours duration, followed by severe lymphopenia, granulocytopenia, thrombocytopenia, and a moderate anemia. The blood picture may show little change other than lymphopenia for 5 to 10 days after exposure, when the white count may fall to 500 cells/mm^3 or lower. The various nitrogen mustards differ in ability to produce these changes.

15. Chronic Physiological Effects:

In severe cases scarring of the cornea may be expected and the iris is frequently left discolored and atrophied. Repeated skin burns may lead to hypersensitivity of the skin, manifested in the same manner as sensitivity to HD (q.v.).

16. Self Aid and First Aid: Same as for HD (q.v.).

17. Tolerable Environmental Concentrations to Uncontrolled Population:

No data.

18. Molecular Weight: 204.5.

19. Purity Range (average):

a. Laboratory Sample. 96 to 99 wt%.

b. Plant Sample.

20. Physical Appearance: Dark to bright yellow liquid.

21. Vapor Density, Relative to Air: 7.1.

22. Liquid Density: 1.24 g/ml @ 25° C.

23. Solid Density:

a. Bulk Density. NA

b. Crystal Density. NA

24. Normal Freezing Point or Melting Point: -3.7° C.

25. Boiling Point: 256° C (calculated); decomposes at 150° C.

26. Vapor Pressure: 0.011 mm Hg @ 25° C.

27. Volatility: 120 mg/m^3 @ 25° C.

28. Viscosity: 5.9 centistokes @ 25° C.

29. Flash Point: High enough not to interfere with military use of the agent.

30. Autoignition Temperature: Decomposes at 150° C; may become explosive. (Properties of War Gases - Vol IV, ETF100/41).

31. Latent Heat of Vaporization: 74 cal/g.

32. Latent Heat of Fusion: Unknown.

33. Vapor-Air Explosive Hazard Range: Unknown.

34. Relative Persistency:

a. Soil. Persistent.

b. Surface (Wood, Metal, Masonry, Rubber, Paint). Persistent.

c. Water. Not completely hydrolyzed by water after standing for days.

35. Solubility (g/100 g solvent):

a. Water (distilled). 0.008 g/100 g solvent.

b. Other. Soluble in ether, benzene, and most organic solvents.

c. Best Solvent. Organic solvents.

Nitrogen Mustard

36. Thermal Decomposition Rate: Decomposes at 150° C. Process may become explosive. Unstable at room temperature in glass.

37. Heat of Combustion: Unknown.

38. Products of Combustion: CO_2, HCl, Cl_2, H_2O, N_2 estimated for furnace incinerator.

39. Rate of Hydrolysis:

a. Acidic (pH). Very slow.

b. Basic (pH). Hydrolysis is more rapid under basic conditions.

40. Hydrolysis Products: $N(CH_2CH_2OH)_3$ in dilute solutions; dimer formation in higher concentrations.

41. Corrosive Properties: Does not attack iron in the absence of water. Penetrates steel at the rate of 1×10^{-5} to 5×10^{-5} inches/month at 65° C.

42. Detection Methods and Equipment: DB-3 Test, Spotted Disk (SD) Test, Dragendorff Test; otherwise, same as H.

43. Decontaminants:

a. Personnel. M13 kit (liquid on skin, clothing, or equipment). M5 ointment.

b. Equipment. Bleach, DANC solution. DS2.

c. Areas (Terrain). Fire, earth moving equipment; STB slurry sprayed from M9 or M12A1 decontaminating apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

a. Laboratory Sample. Rate of polymerization decreases with addition of CS_2 & $\emptyset_3COH$ (carbon disulfide, triphenyl carbinol).

b. Production Sample. Same.

46. Types of Containers Required for Storage:

a. RDT&E Quantities. Glass with stabilizer.

b. Stockpile Quantities. Stable in high carbon steel at 25° for 40-50 weeks or low carbon steel with stabilizer. Polymerizes when stored at 65° C.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: A

Next page is blank.

1. Chemical Code or EA Number: HT; standard HT is 60% HD and 40% T by weight.

2. Chemical Name:

   HD Bis(2-chloroethyl) sulfide;
   T Bis[2(2-chloroethylthio)ethyl] ether.

3. Chemical Formulae:

   a. Empirical.

      HD $C_4H_8Cl_2S$
      T $C_8H_{16}Cl_2OS_2$

   b. Structural.

      HD $ClCH_2CH_2SCH_2CH_2Cl$ MW 159.08

      T $(ClCH_2CH_2SCH_2CH_2)_2O$ MW 263.3

4. Biological Type Compound: Lethal Agent.

5. Principal Pharmacological Action: HT is a vesicant. In addition to causing blisters, it irritates the eyes and is toxic when inhaled.

6. Characteristic Odor: Garlic-like.

7. Effective Routes of Administration: Ocular, percutaneous, inhalation, injection, ingestion.

8. Median Lethal Dosage, Man: None established by any route.

9. Median Lethal Dosage, Animals:

   a. Inhalation (LCt_{50}'s).

      Mice - 1,100 mg min/m^3 (10-day observation)
      820 mg min/m^3 (15-day observation)
      Dogs - 100 to 200 mg min/m^3 lethal
      Guinea Pigs - 3,000 to 6,000 mg min/m^3 lethal
      Rabbits - 3,000 to 6,000 mg min/m^3 lethal

HT (60% HD, 40% T)

b. Percutaneous. No data.

c. Subcutaneous.

Guinea pigs - LD_{50}, 50 mg/kg body weight, lethal.

10. Median Incapacitating Dosage:

a. Man. None established by any route.

b. Animals. Unknown.

11. Threshold Limit Value. Unknown.

12. Minimum Effective Dosage:

a. Percutaneous, Man.

HT sprayed in drops of 1.75 mm diameter (ca 3.5 mg) or larger through most parts of soldiers' ordinary S. D. clothing causes vesication of the skin. HT sprayed in drops of 3 mm diameter (18 mg) usually fails to produce vesication through cardigan and great coat plus service dress. Varying degrees of erythema may be produced.

HT applied to arms of five men in drops of 0.012 mm^3.

Maximum blister area 10 mm^2; number blisters/number applications 10/10; area of erythema at 48 hours, 35 mm^2.

b. Eye, Animal.

HT causes eye lesion in rabbits of H type and of about the same severity.

13 & 14. Acute and Chronic Physiological Effects:

HT applied to the skin of man has the same type of vesicant action as mustard, but appears to be more active.

HT on inhalation by mice causes burning of the ears, swelling of the eyelids, yellow exudate from eyes, a marked loss of appetite, emaciation and roughness and dullness of the fur.

15. Onset Time of Symptoms: No data.

16. Self Aid and First Aid: Same as Item 16 for Chemical Agent HD.

17. Tolerable Environmental Concentrations to Uncontrolled Population: No data.

18. Molecular Weight: 189.4 (average), based on 60/40 wt%

19. Purity Range:

    a. Laboratory Sample.

    b. Plant Sample.

20. Physical Appearance: Clear to pale yellow liquid, highly viscous.

21. Vapor Density, Relative to Air: 6.92, based on 60/40 mixture.

22. Liquid Density: 1.269 g/ml @ 25°C.

23. Solid Density:

    a. Bulk Density. Not applicable.

    b. Crystal Density. Not applicable.

24. Normal Freezing Point or Melting Point: 0.0 to 1.3° C for 60/40 mixure.

25. Boiling Point: Above 228° C. No constant boiling point. The H fraction is removed by distillation.

26. Vapor Pressure: 0.104 mm Hg @ 25° C.

27. Volatility: 831 mg/m^3 @ 25° C.

28. Viscosity: 6.05 centistokes at 20° C.

29. Flash Point: See HD (about 100° C).

30. Autoignition Temperature: Unknown.

HT (60% HD, 40% T)

31. Latent Heat of Vaporization: No data available. HD is more volatile than T; it boils of and the composition of the mixture changes.

32. Latent Heat of Fusion:

33. Vapor-Air Explosive Hazard Range: Unknown.

34. Relative Persistency

    a. Soil. Persistent.

    b. Surface (Wood, metal, masonry, rubber, paint). Permeates ordinary rubber.

    c. Water. Persistent due to poor solubility.

35. Solubility:

    a. Water (distilled). Practically insoluble.

    b. Other. Soluble in most organic solvents.

    c. Best Solvent.

36. Thermal Decomposition Rate: Decomposes at 165° - 185° C.

37. Heat of Combustion: 5240 cal/g for 20-year old samples.

38. Products of Combustion: CO_2, Cl_2, H_2O, H_2SO_4, HCl (bomb calorimetry).

39. Rate of Hydrolysis:

    a. Acidic. Poor solubility; hydrolyzes only after prolonged boiling in water.

    b. Basic. Hydrolyzes in caustic alkalis.

40. Hydrolysis Products: See data on HD.

41. Corrosive Properties: Pressure develops in steel.

42. Detection Methods and Equipment:

For Liquid: ABC-M8 detector paper; M6A1 detector paper.

For Vapor: M15A2, M18A2 kits (DB-3 or blue band test).

43. Decontaminants:

a. Personnel. Flush eyes with water.
M13 kit (liquid on skin or clothing).
M5 ointment.
Shower with soap and water.

b. Equipment. Bleach. DANC solution. D52 solution.

c. Areas (Terrain). Fire, aeration, STB slurry sprayed by M9 or M12A1 decontaminating apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

b. Production sample.

46. Types of Containers Required for Storage:

a. RDT&E Quantities: Glass.

b. Stockpile Quantities. One-ton steel containers.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: A

Next page is blank.

1. Chemical Code or EA Number: L

2. Chemical Name: Dichloro-2-chlorovinylarsine, lewisite.

3. Chemical Formulae:

   a. Empirical. $C_2H_2AsCl_3$

   b. Structural. $ClCH=CHAsCl_2$

4. Biological Type Compound: Lethal agent.

5. Principal Pharmacological Action: L is a vesicant. It produces effects similar to HD but, in addition, acts as a systemic poison, causing pulmonary edema, diarrhea, restlessness, weakness, subnormal temperature, and low blood pressure. In order of severity and appearance of symptoms it is: a blister agent, a toxic lung irritant, and when absorbed in the tissues, a systemic poison. Liquid L causes an immediate searing sensation in the eye and permanent loss of sight if not decontaminated within 1 minute. L produces an immediate and strong stinging sensation to the skin; reddening of the skin starts within 30 minutes. Blistering does not appear until after about 13 hours. Like HD, it is a cell poison. Skin burns are much deeper than with HD. When inhaled in high concentrations it may be fatal in as short a time as 10 minutes. The body does not detoxify L.

6. Characteristic Odor: Usually geraniumlike; very little odor when pure.

7. Effective Routes of Administration: Ocular, percutaneous, inhalation, injection.

8. Median Lethal Dosage, Man (LCt_{50}'s):

   a. Inhalation. 1200-1500 mg min/m^3.

   b. Percutaneous. Vapor, masked personnel, 100,000 mg min/m^3.

When humidity is high, L hydrolyzes so rapidly that it is difficult to maintain a concentration sufficient to blister bare skin. This difficulty is further increased by the high vapor pressure and and short duration of effectiveness of L.

Lewisite

9. Median Lethal Dosage, Animals:

a. Total Exposure, Vapor, head and body unprotected

Species	t	LCt_{50}
	min	mg min/m^3
Mouse	10	900-1400 (nominal concn)
	10	2800 (nominal concn)
	10	1500 (anal. concn)
	10	2500-2800 (nominal concn)
	9-14	500 (anal. concn)
Rat	9-25	1500 (anal. concn)
	60-180	580 (anal. concn)
Guinea Pig	9-14	1000 (anal. concn)
	60-180	470 (anal. concn)
Rabbit	7.5-13	1200 (anal. concn)
	60-310	1500 (anal. concn)
Goat	100-255	1250 (anal. concn)
Dog	7.5-15	1400 (nominal concn)

b. Inhalation, Vapor, head exposed, body protected.

Species	t	LCt_{50}
	min	mg min/m^3
Mouse	10	1400-1500 (nominal concn)
	10	1600 (nominal concn)
	10	1500 (anal. concn)

c. Percutaneous.

(1) Vapor, body exposed, head protected.

Species	t	LCt_{50}	
	min	mg min/m^3	
Mouse	10	1200-1900	(nominal concn)
	10	300	(nominal concn)
	10	7000	(nominal concn)
Rat	9-25	20,000	(nominal concn)
Guinea Pig	10-40	20,000-25,000	(nominal concn)
Rabbit	10	15,000	(nominal concn)
Cat	30-45	30,000	(nominal concn)
Dog	30-60	30,000	(nominal concn)
	10	40,000	(nominal concn)

(2) Liquid.

Species	LD_{50}(mg/kg)
Mouse	15
Rat	24
	15
	24
	20
Rabbit	5
	6
	6
Guinea Pig	12
Dog	38
	ca 70
Goat	24
	10

Lewisite

	Route	Species	LD_{50}'s
			mg/kg
d.	Intravenous	Rabbits	2
		Dogs	2 (minimum fatal dose)
e.	Subcutaneous	Rabbits	2
		Guinea Pig	1
f.	Intraperitoneal	Dog	2 (approximate)
		Guinea Pig	2 (minimum fatal dose)
g.	Intramuscular	Rabbits	5-10

10. Median Incapacitating Dosage, Man:

a. Inhalation. No data.

b. Percutaneous, masked personnel. Over 1,500 mg min/m^3, L irritates the eyes and skin and gives warning of its presence.

c. Eyes. Eye injury from vapor, below 300 mg min/m^3.

11. Threshold Limit Value: No data.

12. Minimum Effective Dosage:

a. Man.

(1) Percutaneous, vapor. An approximate concentration of 200 mg/m^3 (exposure time 30 minutes) is necessary to produce lesions on bare skin.

b. Rabbit.

(1) Percutaneous, vapor. An approximate concentration of 25 mg/m^3 (exposure time 30 minutes) is necessary to produce lesions on skin.

(2) Eyes, vapor. An approximate concentration of 1 mg/m^3 (exposure time 30 minutes) is necessary to produce eye lesions.

c. Dog.

(1) Percutaneous, vapor. An approximate concentration of 50 mg/m^3 (exposure time 30 minutes) is necessary to produce skin lesions.

(2) Eyes, vapor. An approximate concentration of 20 mg/m^3 (exposure time 30 minutes) is necessary to produce eye lesions.

13. & 14. Acute Physiological Effects and Onset Time of Symptoms:

a. Acute Exposure.

(1) Eyes.

Liquid arsenical vesicants cause severe damage to the eye. On contact, pain and blepharospasm occur instantly. Edema of the conjunctivae and lids follow rapidly and close the eye within an hour. Inflammation of the iris usually is evident by this time. After a few hours the edema of the lids begins to subside, while haziness of the cornea develops and iritis increases. The corneal injury, which varies with the severity of the exposure, may heal without residuals. Liquid arsenical vesicants instantly produce a gray scarring of the cornea, like an acid burn, at the point of contact. All injured eyes are susceptible to secondary infection. Mild conjunctivitis in man, due to arsenical vesicants, heals in a few days without specific treatment. Severe exposure may cause permanent injury or blindness.

(2) Skin.

Stinging pain is felt usually in 10 to 20 seconds afer contact with liquid arsenical vesicants. The pain increases in severity with penetration and in a few minutes becomes a deep, aching pain. Pain on contact with liquid arsenical vesicants usually gives sufficient warning so that decontamination may be begun promptly and deep burns avoided in conscious victims. After about 5 minutes of contact, there appears a gray area of dead epithelium resembling that seen in corrosive burns. Erythema is like that caused by mustard but is accompanied by more pain. Itching and irritation persist for only about 24 hours whether or not a blister develops. Blisters are often well developed in 12 hours and are painful at first, in contrast to the relatively painless mustard blister. After 48 to 72 hours, the pain lessens.

(3) Respiratory Tract.

The vapors of arsenical vesicants are so irritating to the respiratory tract that conscious men are immediately warned to put on a mask. No severe respiratory injuries are likely to occur except among the wounded who cannot put on masks, and the careless, who are caught without masks. The respiratory lesions are similar to those produced by mustard except, that in the most severe cases, pulmonary edema may be accompanied by pleural effusion.

(4) Systemic Effects.

Liquid arsenical vesicants on the skin, as well as inhaled vapor, are absorbed and may cause systemic poisoning. A manifestation of this is a change in capillary permeability, which permits loss of sufficient fluid from the bloodstream to cause hemoconcentration, shock, and death. In non-fatal cases, hemolysis of erythrocytes has occurred with a resultant hemolytic anemia. The excretion of oxidized products into the bile by the liver produces focal necrosis of that organ, necrosis of the mucosa of the biliary passages with periobiliary hemorrhages, and some injury to the intestinal mucosa. Acute systemic poisoning from large skin burns causes pulmonary edema, diarrhea, restlessness, weakness, subnormal temperature, and low blood pressure in animals.

15. Chronic Physiological Effects: No data.

16. Self Aid and First Aid: Same as Item 16 for Chemical Agent HD.

17. Tolerable Environmental Concentrations to Uncontrolled Population:

No data.

18. Molecular Weight: 207.32.

19. Purity Range:

a. Laboratory Sample.

b. Plant Sample. See MIL Spec 196-21-14A (Jan '44). War gas contains about 10% chloro bis(2-chlorovinyl) arsine.

20. Physical Appearance:

War gas - amber to dark brown liquid; pure L - colorless oily liquid.

21. Vapor Density, Relative to Air: 7.2

22. Liquid Density: 1.88 g/ml @ 25° C.

23. Solid Density:

a. Bulk Density. Not applicable.

b. Crystal Density. Not applicable.

24. Normal Freezing Point or Melting Point: -18° C $\pm$ 0.1° C depending on purity and isomers present.

25. Boiling Point: 190° C.

26. Vapor Pressure: 0.58 mm Hg @ 25° C.

27. Volatility: 6.5×10^3 mg/m^3 @ 25° C.

28. Viscosity: 1.09 centistokes @ 25° C.

29. Flash Point: Does not flash.

30. Autoignition Temperature: Unknown.

31. Latent Heat of Vaporization: 58 cal/g from 0° to 190° C.

32. Latent Heat of Fusion: Unknown.

33. Vapor-Air Explosive Hazard Range: Not available.

34. Relative Persistency:

a. Soil. Intermediate persistency.

b. Surface (Wood, Metal, Masonry, Rubber, Paint).

c. Water. Intermediate persistency due to slight solubility.

35. Solubility:

a. Water (distilled). Slightly soluble.

b. Other. Soluble in Et_2O, $CHCl_3$, all common organic solvents, mustard, oils, alcohol.

c. Best Solvent. Organic solvents.

36. Thermal Decomposition Rate: Degrades to a considerable extent on detonation in shell.

37. Heat of Combustion: Unknown.

38. Products of Combustion:

May produce chlorovinyl arsenous oxide.

39. Rate of Hydrolysis:

Acidic: Rapid, although not soluble.

40. Hydrolysis Products:

a. Acidic. Chlorovinyl arsenous oxide and HCl. (Product has vesicant property.) Chlorovinyl arsenous oxide is a nonvolatile blister-forming solid not readily washed away by rain. Alkaline hydrolysis destroys these blister-forming properties.

b. Basic. $CH{\equiv}CH$ and Na_3AsO_3.

Lewisite

41. Corrosive Properties: 1×10^{-5} to 5×10^{-5} in/month at 65°C in steel. Reasonably inert if water-contamination is prevented.

42. Detection Methods and Equipment:
Cuprous Acetylide Test, and ACU Test.
For Liquid: ABC-M8 detector paper; M6A1 detector paper.
For Vapor: M18A2, M19 kits (yellow band tube).

43. Decontaminants:

a. Personnel. British anti-Lewisite. M13 kit (liquid on skin).

b. Equipment. Bleach, DANC, DS2. NaOH in glycerin, then wash with soap and water.

c. Areas (Terrain). Caustic soda, fire, aeration. STB slurry applied by M9 or M12A1 decontaminating apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

a. Laboratory Sample.

b. Production Sample.

46. Types of Containers Required for Storage:

a. RDT&E Quantities.

b. Stockpile Quantities. Reasonably pure L indefinitely stable in storage. Steel not corroded if sample is moisture-free. Arsenic-containing rust is deposited on walls of steel container.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: A

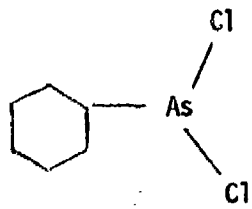
1. Chemical Code or EA Number: PD

2. Chemical Name: Dichlorophenylarsine.

3. Chemical Formulae:

   a. Empirical. $C_6H_5AsCl_2$

   b. Structural.



4. Biological Type Compound: Lethal agent.

5. Principal Pharmacological Action: The toxic chlorarsine derivatives produce effects which are qualitatively similar to those produced by Lewisite (q.v.) but which differ in degree. Thus, they are all irritant to the respiratory tract and produce lung injury on sufficient exposure. The vapors are irritating to the eyes and the liquids may produce serious eye lesions. The absorption of either vapor or liquid through the skin in adequate dosage may lead to systemic intoxication or death. Local skin damage leading to vesication in man is usually produced by sufficient exposure to the vapor or by contact with the liquid. PD also acts as a vomiting agent.

6. Characteristic Odor: Odorless but strongly irritant to nose and throat.

7. Effective Routes of Administration: Inhalation, percutaneous, ocular, ingestion, injection.

8. Median Lethal Dosage, Man:

   a. Inhalation. 2600 mg min/m^3 (t not stated; probably 10 min).

9. Median Lethal Dosage, Animal:

   a. Inhalation.

      Mouse. LCt_{50}: 3300 mg min/m^3 (t = 10 min).

b. Percutaneous (Liquid).

PD equals Lewisite in systemic toxicity when administered to shaved backs of mice.

Compound	Dose mg	% Mortality 10-day period
PD	0.1	20
	0.3	30
	0.5	100
L	0.1	0
	0.3	50
	0.5	100

c. Intravenous (Liquid).

Rabbit. LD_{50}: 0.5 mg/kg.

d. Intraperitoneal (Liquid).

Dog. LD_{50}: 3 mg/kg.

e. Subcutaneous (Liquid).

Dog. LD_{50}: 5 mg/kg.

Rabbit. LD_{50}: 4-6 mg/kg.

Guinea Pig. LD_{50}: 4 mg/kg.

Rat. LD_{50}: 16-20 mg/kg.

f. Body Exposure, Head Protected (Vapor).

Mice. Ct of 6200 mg min/m^3, 30° C and 8% R. H. killed 3/6 mice. Exposure time probably 10-minutes. Concentration was nominal.

10. Median Incapacitating Dose, Man:

a. Inhalation. 10 mg min/m^3 as a vomiting agent.

b. Percutaneous (vapor). 1800 mg min/m^3 as blistering agent.

11. Threshold Limit Value: No data.

12. Minimum Effective Dose:

A 40% solution of PD in diphenyl ether is the minimum concentration which produced blisters in 50% of 70 men when applied with a No. 5 rod to the skin of the forearm. In testing the vesicant effectiveness of compounds these stainless steel or glass rods were touched to the surface of a pad saturated with the vesicant and then applied to the skin. In general the rods have not proved satisfactory for comparison of vesicants since a separate calibration is required for each compound tested. Rod No. 5 has an area tip of 2.69 mm^2 and weighs approximately 40 grams.

13., 14., & 15. Acute and Chronic Physiological Effects and Onset of Symptoms: The effects of PD are similar to those of Lewisite (q.v.).

16. Self Aid and First Aid: Same as Item 16 for Chemical Agent HD.

17. Tolerable Environmental Concentrations to Uncontrolled Populations:

No data.

18. Molecular Weight: 222.91.

19. Purity Range:

a. Laboratory Sample.

b. Plant Sample.

20. Physical Appearance: Colorless liquid.

21. Vapor Density, Relative to Air: 7.7

22. Liquid Density: 1.65 g/ml @ 20° C.

23. Solid Density:

a. Bulk Density. Not applicable.

b. Crystal Density. Not applicable.

24. Normal Freezing Point or Melting Point: -20° C.

25. Boiling Point: 255° C.

26. Vapor Pressure: 0.033 mm Hg @ 25° C.

Dichlorophenylarsine

27. Volatility: 390 mg/m^3 @ 25° C. Vaporizing tendency too low to give it any value as a blister agent in the field. As an aerosol, it is effective against unprotected troops for a short time.

28. Viscosity: 1.95 centistokes @ 25° C.

29. Flash Point: High enough not to affect military use.

30. Autoignition Temperature: Not applicable.

31. Latent Heat of Vaporization: 69 cal/g.

32. Latent Heat of Fusion: 7.7 cal/g.

33. Vapor-Air Explosive Hazard Range: Unknown.

34. Relative Persistency: Persistent.

35. Solubility (g/100 g solvent):

a. Water (distilled). 0.598 in 20 hours at 37° C.

b. Other. Miscible with alcohol, benzene, kerosene, petroleum, and olive oil.

c. Best Solvent. Organic solvents.

36. Thermal Decomposition Rate: Stable to boiling point.

37. Heat of Combustion: Unknown.

38. Products of Combustion: Triphenylarsine, Diphenylchloroarsine at 100° C.

39. Rate of Hydrolysis: Rapid.

40. Hydrolysis Products: Phenyl arsenious oxide (C_6H_5AsO) and HCl. No pH given.

41. Corrosive Properties: Does not attack iron when pure and dry.

42. Detection Methods and Equipment: Molybdenum Blue Test.
For Liquid: ABC-M8 and M6A1 detector papers.
For Vapor: M18A2, M19 kits
(yellow band tube)

43. Decontaminants:

a. Personnel. M13 kit (liquid on skin).

b. Equipment. Bleach, caustic soda, DS2 or DANC.

c. Areas (Terrain). Aeration. STB slurry sprayed by M9 or M12A1 decontaminating apparatus.

44. DOT Classification: Poison B.

45. Stabilizer Utilized:

a. Laboratory Sample. None required. Very stable in storage.

b. Production Sample. Same.

46. Types of Container Required for Storage:

a. RDT&E Quantities. Glass.

b. Stockpile Quantities. Steel drums.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: Unknown.

Next page is blank.

6. Blood Agents. Blood agents are absorbed into the body primarily by breathing. They affect body functions through action on the enzyme cytochromeoxidase, thus preventing the normal transfer of oxygen from the blood to body tissue.

Blood agents described in this volume are:

AC (Hydrogen Cyanide or Hydrocyanic Acid)

CK (Cyanogen Chloride)

Next page is blank.

1. Chemical Code or EA Number: AC

2. Chemical Name: Hydrogen Cyanide or Hydrocyanic Acid.

3. Chemical Formulae:

   a. Empirical. HCN

   b. Structural. HC≡N

4. Biological Type Compound: Lethal, rapid acting.

5. Principal Pharmacological Action:

A systemic poison, a blood agent. It affects bodily functions through action on the enzyme cytochrome-oxidase thereby preventing the normal transfer of oxygen from the blood to body tissue.

6. Characteristic Odor:

Faint odor similar to peach kernels or bitter almonds; sometimes cannot be detected even in lethal concentrations.

7. Effective Routes of Administration:

Inhalation, percutaneous, ocular on contact, and ingestion.

8. Median Lethal Dosage, Man:

   a. Inhalation, resting man, (LCt_{50}'s).

      2,000 mg min/m^3 (t = 0.5 min)
      3,400 " " " (t = 1 min)
      4,400 " " " (t = 3 min)
      6,100 " " " (t = 10 min)
      20,600 " " " (t = 30 min)

   b. Percutaneous.

      Liquid: about 100 mg/kg.

      Vapor: median lethal dosage unknown. 11,000 mg/m^3 reported to be dangerous. Exposure time not known.

   c. Ingestion. Unknown. 50 to 100 mg (0.7 -1.4 mg/kg) may be rapidly fatal.

Hydrogen Cyanide

9. Median Lethal Dosage, Animal:

a. Inhalation.

Species	t	LCt_{50}
	min	mg min/m^3
Mouse	0.5	566
	1.0	911
	10.0	220
	30.0	163
Rat	0.5	769
	1.0	932
	2.0	1095
Rabbit	0.5	904
	1.0	980
Dog	0.5	800
	1.0	616
Cat	0.5	1474
	2.0	1226
Pig	0.5	1740
Sheep	0.5	1441
Goat	0.5	2354
	2.0	1085
Guinea Pig	0.5	2112
Monkey	0.5	1616

b. Percutaneous.

Lethal dosage, mg min/m^3

Mouse: 200,000 (t = 10)
Cat: 550,000 (t = 10)
Dog: 1,160,000 (t = 10)

c. Oral. Lethal dose (liquid), rabbit: 4 mg/kg

d. Ocular. Unknown.

10. Median Incapacitating Dosage, Man: No established ICt_{50}'s could be found.

11. Threshold Limit Value:

11 mg/m^3 with "Skin" notation. This notation refers to the potential contribution to the overall exposure by the cutaneous route including mucous membranes and the eye.

12. Minimum Effective Dosage, Man (Total Body Exposure):

Resting men exposed to Ct's of 550 mg min/m^3 (t = 2 min) and 582 mg min/m^3 (t = 1.5 min) felt no adverse effects, not even dizziness, although these may have occurred upon exertion.

In another direct human exposure to concentrations ranging between 550 and 688 mg/m^3 for 1.5 min (Ct 825-1032 mg min/m^3), the subject showed no signs or symptoms during the exposure period.

Approximately 3.5 minutes after leaving the chamber (5 minutes after start of exposure period), subject suffered a momentary feeling of nausea.

Approximately 8.5 minutes after leaving the chamber (10 minutes after start of exposure period), subject had difficulty in paying attention and in concentrating while engaged in close conversation.

13. Acute Physiological Effects:

a. Inhalation (Total Body, Acute Exposure)..

(1) Initial Symptoms. Brief sensation of dryness and burning in throat from local irritation. Feeling of suffusing warmth, air hunger.

(2) Moderate Symptoms. Hyperpnea sometimes associated with brief outcry; apnea.

(3) Severe Symptoms. Collapse, convulsions. Cardiovascular failure. The heart may continue to beat with various irregularities and blocks for as long as 3-4 minutes after the last gasp. The skin acquires a rose-colored hue.

b. Ingestion (Acute Exposure).

Less acute syndrome than by inhalation route and dominated by central nervous system effects.

(1) Initial and Moderate Symptoms. Hyperpnea and vomiting.

(2) Servere Symptoms. Unconsciousness, generalized convulsions, trismus of jaw muscles, flushed hot and dry skin, dull, rapid, irregular pulse, high systolic with a low diastolic blood pressure, vascular collapse, cyanosis, death.

c. Percutaneous. Vapor, Man (Arm Only Exposed).

Exposure Time min	Concn. mg/m3	Ct mg min/m3	Effects
50	6,000	330,000	None
27	24,000	648,000	Prickling of skin and generalized weakness
22	60,000	1,320,000	3-hr post exposure; heaviness developed

14. Chronic Physiological Effects:

a. Inhalation.

Long exposure to low concentrations may result in prolonged tissue anoxia and damage to the central nervous system resulting in coma and convulsions. Recovery from this condition may disclose a residual damage to the central nervous system manifested by irrationality, altered reflexes, and unsteady gait; these may last for weeks or longer.

15. Onset Time of Symptoms:

Compound acts very rapidly. Exposure to excessive concentrations of vapor may result in instantaneous loss of consciousness and death without warning.

a. Inhalation of High Concentrations.

Few seconds: increased depth of respiration.

20-30 seconds: violent convulsions.

1 minute: cessation of regular respiration.

Few minutes: occasional shallow gasps and cessation of heart action.

b. Ingestion.

Less rapid and more variable absorption from gastrointestinal tract than from the lungs causes a less acute syndrome.

1-5 minutes: hyperpnea and vomiting.

5-20 minutes: unconsciousness, generalized convulsion, trismus of jaw muscles, flushed hot and dry skin, full rapid and irregular pulse, a high systolic with a low diastolic blood pressure, and gasping respiratory efforts.

20- ?: hypoxic dilation of the pupils, vascular collapse, and cyanosis.

16. Self Aid and First Aid:

a. In any chemical incidence, if a sudden stimulation of breathing or an odor like bitter almonds is noticed, put on mask as fast as possible. Speed is absolutely essential; this agent acts so rapidly that within a few seconds its effects will make it impossible for an individual to put on the mask by himself. Every effort should be made to hold the breath until the mask is on. This may be very difficult since the agent strongly stimulates respiration.

b. The first emergency therapeutic measure is the inhalation of amyl nitrite. When the air is free of hydrocyanic acid, crush two ampules of amyl nitrite in the hollow of the hand and hold close to the patient's nose. This may be repeated every few minutes until eight ampules have been used. Artificial respiration should be given if respirations have ceased or are feeble. This will also facilitate the inhalation of the amyl nitrite. The artificial respiration must be continued until spontaneous breathing returns or for 10 minutes after the last sign of heart activity. If the victim is unmasked and hydrocyanic acid vapors are still present in the air, put the mask on for him. The crushed ampules of amyl nitrite, in the dosages given above, must then be inserted in the region of the eyelenses of the protective mask near the deflector tube openings; make certain after the insertion of the amyl nitrite that the seal of the mask around the face is unbroken. Artificial respiration must be instituted on the patient if he is not breathing or if respiration is feeble.

Hydrogen Cyanide

17. Tolerable Environmental Concentrations to Uncontrolled Population:

Unknown.

18. Molecular Weight: 27.0

19. Purity Range:

a. Laboratory Sample. 96 - 99%.

b. Plant Sample. High purity for munitions.

20. Physical Appearance: Colorless, highly volatile liquid (below 26.5° C) or colorless gas.

21. Vapor Density, Relative to Air: 0.95

22. Liquid Density: 0.68 g/ml @ 25° C.

23. Solid Density:

a. Bulk Density. Not applicable.

b. Crystal Density. 0.93 g/cm^3 at -40° C.

24. Normal Freezing Point or Melting Point: -13.3° C.

25. Boiling Point: 25.7° C.

26. Vapor Pressure: 740 mm Hg @ 25° C.

27. Volatility: 1.1×10^6 mg/m^3 @ 25° C.

28. Viscosity: 0.28 centistokes @ 25° C.

29. Flash Point: -18° C (closed cup).

30. Autoignition Temperature: 540° C.

31. Latent Heat of Vaporization: 223 cal/g.

32. Latent Heat of Fusion:

33. Vapor-Air Explosive Hazard Range: 5.6 to 40% by vol in air.

34. Relative Persistency:

a. Soil. Relatively low, less than an hour.

b. Surface (Wood, Metal, Masonry, Rubber, Paint). Low.

c. Water. Stable in solution.

35. Solubility (g/100 g solvent):

a. Water (distilled). Completely miscible at 25° C.

b. Other. Completely miscible with most organic solvents. Many of the resulting mixtures are unstable. Soluble in ether.

c. Best Solvent. Water.

36. Thermal Decomposition Rate (half-life): Impure AC may be explosive when detonated. Forms explosive polymer on standing, decomposes at temperatures above 65° C.

37. Heat of Combustion: Not available.

38. Products of Combustion: Not available.

39. Rate of Hydrolysis (specify half-life):

a. Acidic (pH). Very slow even with 0.5 normal strong acid.

b. Basic (pH). Rapid - with traces of bases or salts.

40. Hydrolysis Products: NH_3, HCOOH, amorphous brown solids.

41. Corrosive Properties: Noncorrosive.

42. Detection Methods and Equipment: M18A2 detector kit, M19 sampling and analyzing kit (Red band detector tube), M8 alarm, XM256 chemical agent detector kit.

43. Decontaminants:

a. Personnel. Remove contaminated clothing. Bathe with soap and water.

b. Equipment. Sodium hydroxide solution or DS2.

c. Areas (Terrain). 5% sodium hydroxide solution applied by the M9 or M12A1 decontaminating apparatus (PDDA).

Hydrogen Cyanide

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

a. Plant Sample - Colbalt and nickel oxalates 0.5 to 1% precipitated on diatomaceous earth, 0.07% H_3PO_4 and 0.25% SO_2.

b. Production Sample. Same as a.

46. Types of Containers Required for Storage: May be stored in steel and other common metals for long periods of time at temperatures up to 65° C without decomposition or corrosion. May form explosive polymer on standing; stable when mixed w/mineral acids or solvents.

47. Q-D Classification: 8.
Compatibility Group: A
Chemical Group: B

1. Chemical Code or EA Number: CK

2. Chemical Name: Cyanogen Chloride.

3. Chemical Formulae:

   a. Empirical. CClN

   b. Structural. Cl-C≡N

4. Biological Type Compound: Lethal agent, rapid acting.

5. Principal Pharmacological Action:

   Systemic effects similar to those of hydrocyanic acid (AC), which disrupts the oxidative processes of the body by inhibiting the essential enzyme cytochrome oxidase. In addition, CK is a highly effective local irritant on the eyes, upper respiratory tract, and the lungs. Pulmonary edema may develop as a result of the irritant action on the lungs.

6. Characteristic Odor: Pungent odor detectable at 2.5 mg/m^3 (1 ppm).

7. Effective Routes of Administration: Inhalation; highly irritant to eyes and mucous membranes.

8. Median Lethal Dosage, Man (LCt_{50}'s):

   a. Inhalation. 11,000 mg min/m^3. Exposure time not stated in source material.

   b. Percutaneous. No data.

   c. Other. No data.

9. Median Lethal Dosage, Animals:

   a. Inhalation.

Species	t	LCt_{50}
	min	mg min/m^3
Mouse	0.5	3,000
	1.0	4,200
	3.0	4,200
	10.0	7,500

Cyanogen Chloride

Species	t	LCt_{50}
	min	$mg\ min/m^3$
Rat	2.0	9,400
	3.0	5,400
	30.0	9,000
Guinea pig	2.0	7,000
	7.5	9,000
	30.0	17,000
Rabbit	2.0	8,000
	7.5	6,000
	30.0	17,000
Dog	1.0	3,800 (nominal concn)
	3.0	4,200 (nominal concn)
	7.5	4,500
	10.0	5,000 (nominal concn)
	30.0	6,000 (nominal concn)
Monkey	1.0	4,400 (nominal concn)
Goat	1.0	4,500
	3.0	6,000
	10.0	7,500

b. Percutaneous. No data.

c. Other.

(1) Intravenous injection.

Species	$LD_{50} \pm$ (2 S. E.) mg/kg
Dog*	2.97±0.09
Goat*	3.43±0.006
Rabbit*	3.15±0.25
Rabbit**	3.30±0.36

* Anesthetized
** Unanesthetized

(2) Stomach Tube Administration. Rat, LD_{50}, approx. 6.0 mg/kg.

10. Median Incapacitating Dosage, Man:

a. Inhalation. ICt_{50}: 7,000 mg min/m^3. Exposure time not stated in source material.

b. Percutaneous. No data.

c. Other. No data.

11. Threshold Limit Value: >1.25 mg/m^3.

12. Minimum Effective Dose, Man: Minimal concentration detectable eye irritation by 27/27 human subjects within 3 minutes: 12.2 mg/m^3.

13. Acute Physiological Effects:

a. Initial. Intense irritation of nose, throat and eyes with coughing, tightness in chest and lacrimation.

b. Moderate. Dizziness, dyspnea, retching, and involuntary urination and defecation.

c. Severe. Convulsions, unconsciousness, and failing respiration.

If above effects are not fatal, signs and symptoms of pulmonary edema may develop.

14. Chronic Physiological Effects: Residual damage to the central nervous system may occur.

15. Onset Time of Symptoms:

a. Initial Symptoms. Immediately upon exposure.

b. & c. Moderate and Severe. At lethal doses, unconsciousness and death occur within a few minutes. Depending on the degree of exposure, the pulmonary effects may develop immediately or may be delayed until the systemic effects have subsided.

Death or recovery from cyanide effects within minutes. Recovery from lung irritant effects prolonged.

Cyanogen Chloride

16. Self Aid and First Aid:

    a. Put on the mask immediately if any irritation of the eyes, nose, or throat is noticed.

    b. The first emergency therapeutic measure is the inhalation of amyl nitrate. If hydrocyanic acid or cyanogen chloride are no longer present in the atmosphere, two ampules of amyl nitrite should be crushed in the hollow of the hand and held close to the patient's nose. This may be repeated every few minutes until a total of eight ampules have been used. Artificial respiration should be given if respirations have ceased or are feeble. This will also facilitate the inhalation of the amyl nitrite. The artificial respiration must be continued until spontaneous breathing returns or until 10 minutes after the last sign of heart activity. If hydrocyanic acid or cyanogen chloride vapors are still present in the air, and the casualty is not already masked, he must have his mask put on for him. The crushed ampules of amyl nitrite, in the dosages given above, must then be inserted in the region of the eyelenses of the protective mask near the deflector tube openings; make certain after the insertion of amyl nitrite that the seal of the mask around the face is unbroken. Artificial respiration must be instituted on the patient if he is not breathing or if respiration is feeble.

17. Tolerable Environment Concentrations to Uncontrolled Population: No data.

18. Molecular Weight: 61.48.

19. Purity Range:

    a. Laboratory Sample. 95 - 99%.

    b. Plant Sample.

20. Physical Appearance: Colorless gas or liquid.

21. Vapor Density, Relative to Air: 2.0.

22. Liquid Density: 1.20 g/ml at 10° C.

23. Solid Density:

    a. Bulk Density. Not applicable.

    b. Crystal Density. Not applicable.

24. Normal Freezing Point or Melting Point: -6.9° C.

25. Boiling Point: 12.9° C.

26. Vapor Pressure: 1000 mm Hg @ 25° C.

27. Volatility: 2.6×10^6 mg/m^3 @ 12.9° C.

28. Viscosity: NA

29. Flash Point: Does not flash.

30. Autoignition Temperature: Nonflammable.

31. Latent Heat of Vaporization: 103 cal/g. This is sufficiently high to provide a satisfactory pancaking effect.

32. Latent Heat of Fusion: 41.8 cal/g.

33. Vapor-Air-Explosive Hazard Range: Not available.

34. Relative Persistency: Relatively nonpersistent.

35. Solubility (g/100 g solvent):

    a. Water (distilled). 6.9 at 20° C.; will polymerize.

    b. Other. CK is completely miscible with almost all common organic solvents, i.e., alcohol, ether. Many of the resulting mixtures are unstable.

    c. Best Solvent: Organic solvents.

36. Thermal Decomposition Rate (half-life): Decomposes above 100° C. CK will stand for 30 days @ 65° C. without excessive decomposition; polymerizes between 40 and 60 days to form $(CNCl)_3$, a solid. May explode.

37. Heat of Combustion: Not available.

Cyanogen Chloride

38. Products of Combustion: Not available.

39. Rate of Hydrolysis:

a. Acidic (pH).

pH 6.6 - 7.06, t 1/2 1.6 hr @ 25° C; pH 4 - 6, t 1/2 58 hr @ 40° C.

b. Basic (pH).

pH 8, t 1/2 18 hr; at room temperature.
pH 7, t 1/2 180 hr (tap water) at room temperature.

40. Hydrolysis Products:

a. Acidic (pH). HCl and HOCN.

b. Basic (pH). NaCl and NaCNO.

41. Corrosive Properties: No action on metals when stabilized. Attacks many common metals when stored unstablized. Will polymerize, may explode.

42. Detection Methods and Equipment: M15A2A, M18A2, M19 kits (DB-3 Test, blue band dector tube), M8 Alarm.

43. Decontaminants:

a. Personnel. None effective.

b. Equipment. Aeration in closed spaces. Sodium hydroxide solution or DS2 on materiel.

c. Areas. Terrain: 5% sodium hydroxide solution sprayed from M9 or M12A1 decontaminating apparatus (PDDA).

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

a. Laboratory Sample. 5% anhydrous, powdered sodium pyrophosphate; propylene oxide; arsenic trichloride.

b. Production Sample. Unknown.

46. Types of Containers Required for Storage: Stabilized CK can be stored in steel up to 100° C. without decomposition or corrosion.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: B

Next page is blank.

7. Choking Agents. Choking agents attack the respiratory tract - the nose, throat, and particularly the lungs. In extreme cases, membranes swell, lungs fill with liquid, and death results from lack of oxygen; these agents literally choke a man to death.

The choking agent described in this volume is CG (Carbonyl Chloride, or Phosgene).

Next page is blank.

1. Chemical Code or EA Number: CG

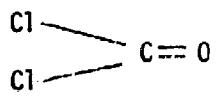
2. Chemical Name: Carbonyl Chloride, or Phosgene.

3. Chemical Formulae:

   a. Empirical.

   CCl_2O

   b. Structural.



4. Biological Type Compound: Lethal agent.

5. Principal Pharmacological Action:

   Phosgene is a lung irritant. The characteristic feature of phosgene poisoning is massive pulmonary edema. The edema results from the passage of fluid into the alveoli from capillaries whose permeability has been affected by the corrosive action of the compound. Hemoconcentration results from loss of plasma into the alveoli. The edema interferes with the interchange of oxygen and carbon dioxide and the capillary blood. Death results from anoxemia and may occur in less than 5 hours.

6. Characteristic Odor: New-mown hay or grass; green corn.

7. Effective Routes of Administration: Inhalation.

8. Median Lethal Dosage, Man (LCt_{50}'s):

   a. Inhalation 3,200 mg min/m^3.

      Since the effects of CG are cumulative, the above Ct is not significantly changed with variations in time of exposure within reasonable limits.

   b. Percutaneous. No data.

   c. Other. No data.

9. Median Lethal Dosage, Animals:

Phosgene

a. Inhalation.

Species	t	LCt_{50}
	min	mg min/m^3
Mouse	2	4,700
	3	1,950
	10	3,800
	30	3,400
Rat	1	6,500
	30	1,400
Guinea Pig	1	2,800
	30	1,300-2,200
Rabbit	30	1,000
Monkey	1	600-1,000
	5	625
	10	750
	30	1,000
Dog	0.5	8,100
	1	8,400
	1	7,000
	3	4,500
	5	4,250
	20	4,200
Goat	2	4,600-6,500
Horse	ca 10	10,000

10. Median Incapacitating Dosage, Man: 1,600 mg min/m^3

During and immediately after exposure, symptoms include coughing, choking, a feeling of tightness in the chest, nausea, and occasionally vomiting, headache, and lacrimation. Some patients with severe cough fail to develop serious lung injury, while others with no signs of early respiratory tract irritation incur fatal pulmonary edema.

11. Threshold Limit Value:

0.4 mg/m^3 (0.1 ppm) is the TLV adopted by the American Conference of Governmental Industrial Hygienists (1972).

0.8 mg/m^3 (0.02 ppm) is the proposed ceiling level for a daily 8-hour exposure of workers. SMUEA-BL, 1972.

12. Minimum Effective Dose, Man: No data.

13. Acute Physiological Effects:

a. Initial Symptoms.

Mild conjunctivitis
Coughing
Tightness in chest
Nausea
Occasional vomiting
Headache

Following the above discomfort, there may be a delay in which the patient has few symptoms, not even abnormal chest signs.

b. Severe Symptoms.

After the delay mentioned above, signs and symptoms of pulmonary edema may occur rapidly, e.g., rapid shallow breathing, painful cough, and marked cyanosis. As the edema progresses, discomfort, apprehension, and dyspnea increase, and frothy, often blood-tinged sputum is raised. Rales and rhonchi are audible in the chest. The patient may go into shock and die.

14. Chronic Physiological Effects:

a. Acute Exposure.

Casualties from acute exposures who survive more than 48 hours usually recover without sequelae. Rarely do bronchitis and bronchiectasis result. However, residual pulmonary deficit may be expected. Neurasthenic symptoms have been the most disabling features observed after recovery from the initial severe symptoms.

b. Chronic Exposure.

Five industrial workers who had been chronically exposed to low concentrations of CG exhibited disturbances in lung function. All of the patients developed the following signs and symptoms over a period of several months with varying degrees of severity: cough, shortness of breath on exertion, and pain or tightness in the chest. Two of the patients also expectorated small amounts of glairy, mucoid sputum. Residual pulmonary deficit may be expected from chronic exposure to CG.

15. Onset Time of Symptoms

a. Initial Symptoms begin during and immediately after exposure. Symptom-free period may last 30 minutes to 24 hours.

b. Severe symptoms may occur rapidly after the symptom-free period above. Death usually occurs within the first 24-48 hours post exposure. Exposure to extremely high concentrations may cause death in 5 hours or less.

16. Self Aid and First Aid:

a. The protective mask should be put on immediately upon detection of the odor of phosgene (like green corn or grass), irritation of the eyes, or change in the taste of a cigarette (smoking may become tasteless or offensive in taste). The individual should hold his breath while masking.

b. If some phosgene has been inhaled, normal combat duties should be continued unless there is difficulty in breathing, nausea, and vomiting, or more than the usual shortness of breath on exertion.

c. If any of the above symptoms occur, the casualty should rest quietly until evacuated by the Medical Service.

17. Tolerable Environmental Concentrations to Uncontrolled Populations:

0.0025 mg/m^3 is the proposed ceiling level for general population.

18. Molecular Weight: 98.9

19. Purity Range:

a. Laboratory Sample. 99+%

b. Plant Sample. MIL SPEC 192-21-3B required 98.0% minimum purity.

20. Physical Appearance: Colorless gas at room temperature.

21. Vapor Density, Relative to Air: 3.4

22. Liquid Density (g/ml): 1.37 g/ml @ 20° C.

23. Solid Density:

a. Bulk Density. Not applicable.

b. Crystal Density. Not applicable.

24. Normal Freezing Point or Melting Point: -128° C.

25. Boiling Point: 7.6° C.

26. Vapor Pressure: 1400 mm Hg @ 25° C.

27. Volatility: 4.3×10^6 mg/m^3 @ 7.6° C.

28. Viscosity: 0.27 centistokes @ 0° C.

29. Flash Point: Does not flash.

30. Autoignition Temperature: Unknown.

31. Latent Heat of Vaporization: 59 cal/g.

32. Latent Heat of Fusion: Not available.

33. Vapor-Air Explosive Hazard Range: Not available.

34. Relative Persistency: Nonpersistent.

35. Solubility (g/100 g solvent @ 25° C):

a. Water (distilled). Very slight, with decomposition.

b. Other. Very soluble with almost all organic solvents, i.e., benzene, toluene. Unstable in some.

c. Best Solvent. Organic Solvents.

Phosgene

36. Thermal Decomposition Rate (half-life): Decomposes at 800° C.

37. Heat of Combustion: -41.8 kcal/mole (estimated).

38. Products of Combustion: CO_2 & Cl_2

39. Rate of Hydrolysis (specify half-life): 0.25 second @ 13° C. No pH given.

40. Hydrolysis Products:

    a. Acidic (pH). HCl and CO_2.

    b. Basic (pH). NaCl and Na_2CO_3.

41. Corrosive Properties: No appreciable corrosion in steel after 1 year at 20° C. Not corrosive when dry.

42. Detection Methods and Equipment: M18A2, M19 Kits. (PDB Test - Green band detector tube), M8 alarm.

43. Decontaminants:

    a. Personnel. If liquid, M13 Kit and M5 ointment.

    b. Equipment. Water, followed by DS2 or by 10% solution of caustic soda or sodium carbonate. Caustic soda is not recommended for fabrics, canvas, and leather.

    c. Areas. Aeration in closed area. Decontamination not required in the field.
    Terrain - Plain water, followed by 5% sodium hydroxide sprayed from M9 or M12A1 decontaminating apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

    a. Laboratory Sample. Stable when dry.

    b. Production Sample. Same as a.

46. Types of Container Required for Storage: Reaction with metal depends on purity. When dry, no reaction; when wet, vigorous corrosion. Requires refrigeration for filling shell. Stored in steel cylinders and special 1-ton containers.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: B

Next page is blank.

8. Incapacitating Agent. Incapacitating chemical agents are capable of producting physiological or mental effects that prevent exposed personnel from performing their military duties for a significant period of time. Recovery from these effects is usually complete. Incapacitating agents fall into two general groups:

a. Those which produce temporary physical disability such as paralysis, blindness, or deafness.

b. Those which produce temporary mental aberrations. Because the effects from these agents are temporary, they resemble riot control agents in this respect.

Incapacitating agents defined in this volume are:

BZ (3-Quinuclidinyl Benzilate)

DM (Adamsite)

Next page is blank.

3 - Quinuclidinyl benzilate

9. Median Lethal Dosage, Animals:

a. Inhalation.

Species	t	LCt_{50}
	min	mg min/m^3
Mouse	5-10	12,000
Rat	5-30	64,000
Guinea Pig	5-30	123,000
Rabbit	15-40	32,000
Dog	6-16	25,000
Monkey	6-25	37,000

b. Percutaneous. Median lethal dose not known. Cycloplegic doses in mg/kg (solvent 30% cresol and 70% alcohol). Cycloplegic doses paralyze the ciliary muscle; this affects the shape of the lens in visual accommodation.

Rabbit, 0.050 (approx.)
Cat, 0.100 (approx.)
Dog, 0.500 (approx.)
Goat, 0.500 (approx.)
Monkey, 0.250 (approx.)

c. Oral. LD_{50}'s for Rabbits: 300 mg/kg (approx.)
Cats: 50 mg/kg (approx.)

d. Intravenous Injection.

Species	LD_{50}'s
	mg/kg
Mouse	14.1
Guinea Pig	10.0
Rabbit	10.0
Monkey	10.4
Swine	4.8
Dog	9.6
Goat	6.7
Rat	14.0

10. Median Incapacitating Dosage, Man·

    a. Inhalation. 70-kg man, t=<5 min., aerosol, particle size of 0.8μ median mass diameter.

Breathing rate	BZ base	BZ HCL
10 l/min	152 mg min/m^3	170 mg min/m^3
15 l/min	101 " "	112 " "

    b. Percutaneous. Not known.

    c. Intramuscular or Intravenous. Approx. 0.0055 mg/kg (base equivalent).

11. Threshold Limit Value: Unknown.

12. Minimum Effective Dose:

    a. Mouse, Intravenous Injection. 0.0316 mg/kg, mydriasis.

    b. Man, Intravenous or Intramuscular.

    In half the population, 0.0025 mg/kg produces a mild but behaviorally significant reduction of performance capability. The criterion currently in use is the Number Facility (NF) test of the Texas Battery. A response is considered positive if the mean of the three lowest test scores is less than 75 percent of a pretest baseline. 0.0027 mg/kg produces an increase in heart rate.

13. Acute Physiological Effects:

    a. Initial Symptoms.

    Increase in heart rate to a peak of 80-85, less than 10 points elevation in blood pressure, moderate dilatation of pupils and slight blurring of vision, sleepiness, slight drying of mouth, some mental slowing, no loss of contact with reality.

b. Moderate Symptoms.

Increase in heart rate to a peak of 85-95, lowest performance scores of about 40 percent in 8 hours, and less than 20 points elevation in blood pressure. Symptoms described for mild response are more severe but still less than maximal. Sedation may be marked during 4 to 16 hour period. Fleeting illusions or hallucinations may occur. Brief lapses in concentration and transient confusion are common. Recovery complete by 72 hours.

c. Severe Symptoms.

Peak heart rate 95 to 110 in 3 to 4 hours. Most subjects approach or reach zero level of performance within 6 hours and do not return above 50 percent before 24 to 36 hours. Hallucinations, confusion, hyperactive disorganized behavior, incoherent speech, and disturbances in memory and attention characteristically appear following an early period of deep sleep or stupor. Recovery complete by 96 hours.

d. Maximal Symptoms.

Heart rate reaches peak values of 110 to 140 within 3 hours. Blood pressure rise of 20 to 60 mm Hg systolic. Rapid onset of stupor within 4 hours, often preceded by period of agitation. Performance deteriorates to zero within 3 to 4 hours. Stupor subsides at 10 to 15 hours, followed by protracted period of sleeplessness, disorganized random behavior, continual hallucinations, and sometimes impulsive outbursts of fear or anger based on misinterpretations of surrounding. Delirium subsides within 72 hours; recovery complete by 120 hours.

14. Chronic Physiological Effects:

Cumulative studies with BZ indicate that daily doses (for 7 days) of 0.5 mg/kg IM (intramuscularly) may be tolerated without apparent cumulative effect. Daily doses of 1 mg/kg daily (for 8 days) are capable of producing mild cumulative effects in some subjects, with a suggestion of tolerance in others. Two micrograms per kilogram administered daily (for 3 days) produced marked cumulative effects in four subjects and manifestations of confusion, disorientation, and other symptoms of delirium on the third day.

In subjects exposed to a second dose of BZ 2 to 3 weeks following the first dose, the onset of symptoms and signs was accelerated and the severity exceeded the degree expected for the dose given; effects subsided earlier than was expected, so that partial recovery was in evidence within 24 hours and full recovery was within the normal period for the specific dose given.

15. Onset Time of Symptoms, Man:

a. At the minimum effective dose, the maximum effective time based on results of the Number Facility Test: 5 hours. Based on physiological signs, i.e., increase in heart rate: 5 hours.

b. At ICt_{50}, (inhalation)

Onset Time hr	Symptoms
2-4	Marked decrease in perception. Loss of responsiveness to visual, auditory, tactile, and painful stimuli.
2-6	Nausea, some subjects vomit. Salivation inhibited. Restlessness.
3-4	Heart rate increases to 120-150.
3-6	Individual attempts to respond to orders but is confused and uncoordinated.
4	Hallucinations and delusions.
4-6	Decreased sweating, flushed skin, oral temperature rises to 99-100 in 70° environment, higher in warmer environment.
4-8	Marked impairment in muscular coordination, cannot dress or feed self, or walk.
5-6	Blood pressure rises to 140/100.
10	Maximum dilation of pupils (8 min). Blurred near vision.

3 - Quinuclidinyl benzilate

<12	Increased random behavior. As confusion increases, wandering, stumbling, fumbling, undressing, and other poorly organized behavior is seen.
12	Sl decrease in muscular strength during first 12 hours; urinary retention due to decreased bladder function during first 12 hours.
>12	Activity level increases and becomes less random, more organized. Shouting, jumping, taking things apart, climbing, conversing with imaginary people.
24-36	Individual may succeed in driving cars, firing weapons but in an indiscriminate and senseless manner. Paranoid thinking may emerge leading to homicidal or suicidal mania.
36-72	Duration of incapacitation

16. First Aid:

The most important considerations are:

a. If the patient is stuporous or comatose, be sure that respiration is unobstructed and turn him on his stomach with head to the side to avoid aspiration in case vomiting should occur.

b. If body temperature is elevated above 102° F and mucous membranes are dry, immediate and vigorous cooling (as for heat stroke) is indicated. Such cases are almost always the result of anticholinergic intoxication. Rapid evacuation should then be accomplished since treatment with appropriate medication may be lifesaving.

c. Reassurance and a firm but friendly attitude by personnel adminstering the first aid will be beneficial if the individual appears to comprehend what is being said to him. Conversation is a waste of time if the individual is incoherent or cannot comprehend what is being said. In such cases the less said the better; the patient will benefit more from prompt and vigorous restraint and evacuation to a treatment facility.

d. Although anticholinergic poisoning may produce alarming dryness and coating of the lips and tongue, there is usually no danger of immediate dehydration, and fluids should be given sparingly, if at all, because of the danger of vomiting and also because of possible temporary urinary retention caused by paralysis of bladder smooth muscle. Cleansing the mouth with an astringent swab may be comforting and will reduce the foul breath associated with parching of the membranes.

e. Weapons and other potentially harmful materials should be removed from the individuals who are suspected casualities. Those include cigarettes, matches, medications, and small items which might be ingested accidentally; delirious patients have been known to attempt to eat items bearing only a superficial resemblance to food.

17. Tolerable Environmental Concentrations to Uncontrolled Population:

Unknown.

18. Molecular Weight: 337.4

19. Purity Range

a. Laboratory Sample. 90-99%.

b. Plant Sample. 80 to 99%.

20. Physical Appearance: Beige to white crystalline solid.

21. Vapor Density, Relative to Air: 11.6

22. Liquid Density: Not applicable.

23. Solid Density:

a. Bulk Density. 0.51 g/cm^3.

b. Crystal Density. 1.33 g/cm^3.

24. Normal Freezing Point or Melting Point: 167.5° C.

25. Boiling Point: 412° C (extrapolated).

26. Vapor Pressure: Negligible, 3 x 10^{-2} microns Hg @ 70° C.

27. Volatility: Negligible, 0.47 mg/m^3 @ 70° C.

3 - Quinuclidinyl benzilate

28. Viscosity: Not applicable.

29. Flash Point: 246° C.

30. Autoignition Temperature: Not applicable.

31. Latent Heat of Vaporization: 62.9 cal/g between 170° - 194° C.

32. Latent Heat of Fusion: 30 cal/g.

33. Vapor-Air Explosion Hazard Range: Not available.

34. Relative Persistency:

    a. Soil. Very persistent.

    b. Surface (Wood, Metal, Masonry, Rubber, Paint). Persistent.

    c. Water. Persistent.

35. Solubility (g/100 g solvent):

    a. Water (distilled). 0.00118 @ 25° C.

    b. Other.

    Greater than 173 Acetic acid, 15 $CHCl_3$
    39 ϕ-CH_2Cl
    19.5 ϕCH_2OH

    c. Best Solvent: Acetic acid.

36. Thermal Decomposition Rate (halflife):

    Pyrolysis occurs at 170° C after prolonged periods. Yields CO, CO_2, benzophenone, benzhydrol. Rate of decomposition is dependent on type of impurities.

37. Heat of Combustion: Unknown.

38. Products of Combustion: Unknown.

39. Rate of Hydrolysis (specify half-life):

    a. Acidic (pH).

    pH 0, 9.5 hours, 100° C.
    pH 7, 3-4 weeks in air 25° C.

    b. Basic (pH).

    pH 7.4, 95 hours, 37° C; pH 9.8, 400 minutes, 25° C
    pH 9, 10 hours 37° C; pH 13, 2 minutes, 25° C.

40. Hydrolysis Products:

    a. Acidic (pH). 3 - quinuclidinol and benzilic acid.

    b. Basic (pH). 3 - quinuclidinol and benzilic acid.

41. Corrosive Properties:

    Lightly attacks aluminum and anodized aluminum after 3 months at 71° C. No effect on steel or stainless steel after 3 months.

42. Detection Methods and Equipment:

    Experimental INCAP kit.

43. Decontaminants:

    a. Personnel. Wash with soap and water.

    b. Equipment. Hot soapy water (materiel). Hypochlorite or chlorination in acid.

    c. Areas. Alcoholic caustic; hot soapy water.

44. DOT Classification: Poison B.

45. Stabilizer Utilized:

    a. Laboratory Sample. None.

    b. Production Sample. None.

3 - Quinuclidinyl benzilate

46. Types of Containers Required for Storage: Stable in most materials.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: B

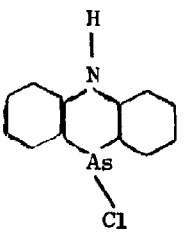
1. Chemical Code or EA Number: DM

2. Chemical Name: 10 chloro- 5, 10 dihydrophenarsazine, Adamsite.

3. Chemical Formulae:

   a. Empirical. $C_{12}H_9AsClN$

   b. Structural.



4. Biological Type Compound: Incapacitating sternutator.

5. Principal Pharmacological Action:

DM produces strong pepper-like local inflammation of the upper respiratory tract, the nasal accessory sinuses, with irritation of the eyes and lacrimation. It causes violent uncontrollable sneezing, coughing, nausea, vomiting, and a general feeling of malaise.

6. Characteristic Odor: No pronounced odor; irritates nasal passages similar to pepper.

7. Effective Routes of Administration: Inhalation, percutaneous, injection, oral.

8. Median Lethal Dosage, Man (LCt_{50}'s):

   a. Inhalation. (Single exposures of 4 hours or less.)

   11,000 mg min/m^3 - pure DM dispersed by laboratory methods (as a dry dust, form solvent sprays or by volatilization-condensation).

   35,000 mg min/m^3 - dispersed from Federal Laboratories No. 113 Spedeheat Grenade.

   44,000 mg min/m^3 - dispersed from M6A1 military grenade.

Adamsite

9. Median lethal Dosage, Animal:

a. Inhalation (LCt_{50}'s).

Species	Pure DM	M6A1 Grenade	No. 113 Grenade
		mg min/m^3	
Monkey	17,837	19,569	22,814
Dog	7,888	28,193	28,428
Swine	56,364	36,011	35,888
Goat	12,135	8,076	11,723
Rabbit	2,903	41,159	46,959
Rat	19,234	66,856	48,217
Guinea Pig	4,623	12,591	29,888
Mouse	46,245* (1918-1965)		
All rodents	10,951	83,380	37,980
Nonrodents	10,233	24,462	30,063
All species	12,306	43,808	34,683
No. of animals	407	473	656

*These animals are not included in the total number of animals listed below for pure DM.

b. Intraperitoneal. Dog. 10 mg/kg body weight kills a dog.

10. Median Incapacitating Dosage, Man.

a. Inhalation, ICt_{50}: 370 mg min/m^3 (nausea and vomiting).

11. Threshold Limit Value: No data.

12. Minimum Effective Dosage, Man:

Lowest intolerable concentration.

Concentration	Time of Exposure
mg min/m^3	minute
22	1
3.6	5
3.45	15
8.40	60

The lowest concentrations (sprayed from alcoholic solutions) that are irritating to the throat and lower respiratory tract are 0.38 and 0.5 mg/m^3, respectively. The lowest concentration causing cough is 0.75 mg/m^3.

13. Acute Physiological Effects:

a. Single Exposures.

DM produces a feeling of pain and a sense of fullness in the nose and sinuses, accompanied by a severe headache, intense burning in the throat, and tightness and pain in the chest. Irritation of the eyes and lacrimation are produced. Coughing is uncontrollable, sneezing violent and persistent. Nasal secretion is greatly increased, and quantities of ropy saliva flow from the mouth. Nausea and vomiting are prominent. Mental depression may occur during progression of symptoms.

Mild symptoms, caused by exposure to very low concentrations, resemble those of a severe cold. The onset of symptoms may be delayed for several minutes after initial exposure, and effective exposure may, therefore, occur before the presence of the smoke is suspected.

If the mask is then put on, symptoms will increase for several minutes in spite of adequate protection. As a consequence, the victim may believe his mask is ineffective and by removing it cause himself to be further exposed.

Symptoms of exposure to field concentrations usually disappear in 20 minutes to 2 hours, leaving no residual injury. A few instances of severe pulmonary injury and death have occurred due to accidental exposures to high concentrations in confined spaces.

b. Repeated Exposures.

Monkeys, dogs, and guinea pigs were exposed to DM aerosols (No. 113 grenade) on 10 consecutive days. The daily doses were approximately at the LCt_5 level. A similar group of animals was exposed to approximately the LCt_{20} to 25 level on each of 10 days. In both cases, the accumulated doses would be expected to kill all animals if the total dose were given in a single exposure.

The lower dose level killed five out of eight monkeys. This is more than would be expected from any one of the exposures alone, but less than would be expected from the total accumulated dose. The deaths among the dogs and guinea p gs at the low dose level were less than would have been expected from any of the single exposures and far less than would be expected from the accumulated dose.

The deaths in monkeys and guinea pigs at the high dosage level are slightly greater than that which would have been expected for the greatest single dose. The deaths in dogs were less than would have been expected of the greatest single dose. There was little indication of cumulative toxicity due to the repeated exposures.

14. Chronic Physiological Effects:

a. A survey was made at Edgewood Arsenal of 39 women exposed to various concentrations.

Thirty-one workers who had been subjected to DM dust from 4 to 6 weeks were studied. Most of these workers had become entirely free of the initial eye and nose symptoms. This hardening process took several days to a week and the tolerance was readily lost within several days away from DM. Exposure to a much heavier concentration usually led to a return of symptoms. Epistaxis was observed in two workers after heavy exposures. Chronic hoarseness was present in one-quarter of the patients, burning of the skin in one-third, and hyperpigmentation of the skin in one-third of the subjects studied. Acute dermatitis was present in one-quarter of the patients.

Eight patients with moderately heavy chronic exposure had become tolerant to the action on the respiratory tract except for slight chronic conjunctivitis and persistent hoarseness in a few cases. Posterior cervical lymph node enlargement was noted in two cases and enlargement of the parotid gland in one. The vital capacity was reduced between 40 and 80% of normal in 70%. X-ray of the lungs showed no change attributable to DM exposure.

b. Dermatitis.

By far the most disturbing result of prolonged exposure to DM is the dermatitis which appears in a quarter of the workers so exposed.

(1) Individual variations in tolerance are very large and undoubtedly play a part in the development of dermatitis.

(2) The effect of concentration of DM. Dermatitis may develop in workers exposed to only a very light concentration. Heavy concentrations certainly play a part in the precipitation of frank dermatitis in certain workers.

(3) Effect of moisture and heat. These factors probably increase the sensitivity of the skin and certainly precipitate dermatitis.

(4) Incubation period. Almost every case of dermatitis began three weeks after the beginning of exposure.

(5) Avoidance of DM after dermatitis developed did not result in improvement in the severe cases. In a very mild early case, avoidance of DM was sometimes followed by remission.

(6) Effect of prolonged exposure. Many subjects continued to work with a severe dermatitis. In some of these the dermatitis improved despite continued exposure. In most of the cases the dermatitis persisted.

15. Onset Time of Symptoms: See Items 13 and 14.

16. Self Aid and First Aid:

Put on mask and wear it in spite of coughing, sneezing, salivation, and nausea. Lift the mask from the face briefly if necessary to permit vomiting or to drain saliva from the facepiece. Carry on duties as vigorously as possible; this will help to lessen and shorten the symptoms. Combat duties usually can be performed in spite of the effects of sternutators.

17. Tolerable Environmental Concentrations to Uncontrolled Population: No data.

18. Molecular Weight: 277.57

19. Purity Range:

    a. Laboratory Sample. 95 to 99%.

    b. Plant Sample.

20. Physical Appearance: Light yellow to dark yellow-green solid, depending on crystal phase.

21. Vapor Density, Relative to Air: 9.6. Does not vaporize at ordinary temperatures; must be dispersed as an aerosol through application of heat.

22. Liquid Density: Not applicable.

23. Solid Density:

    a. Bulk Density. Less than 1 g/cm^3.

    b. Crystal Density. 1.65 g/cm^3 @ 20° C.

24. Normal Freezing Point or Melting Point: 195° C.

25. Boiling Point: 410° C with decomposition.

26. Vapor Pressure: 4.5×10^{-11} mm Hg @ 25° C.

27. Volatility: Not of practical significance.

28. Viscosity: NA

29. Flash Point: Does not flash.

30. Autoignition Temperature: Unknown.

31. Latent Heat of Sublimation: 134 cal/g @ 170° to 195° C.

    Latent Heat of Vaporization: 80 cal/g @ 200° to 250° C.

32. Latent Heat of Fusion:

33. Vapor-Air Explosive Hazard Range: Not available.

34. Relative Persistency:

a. Soil. Persistent.

b. Surface (Wood, Metal, Masonry, Rubber, Paint). Persistent.

c. Water. Persistent. When material is covered with water, an insoluble film forms which prevents further hydrolysis.

35. Solubility (g/100 g solvent):

a. Water (distilled). 0.0004 at room temperature.

b. Other.

Tetrachlorethane	1.16 @ 17° C
Chlorobenzene	1.06 @ 16° C
Benzene	2.3 @ 15° C

c. Best Solvent.

Acetone	13.03 @ 15° C

36. Thermal Decomposition Rate (half-life): Not available.

250° C, 0.15% per minute.

37. Heat of Combustion: Unknown.

38. Products of Combustion: Unknown.

39. Rate of Hydrolysis:

a. Acidic (pH). 0.5% HCl; prevents hydrolysis at room temperature. 0.8% HCl; prevents hydrolysis at 70°C.

b. Basic (pH). Slowly hydrolyzes in water; see Item 34.

40. Hydrolysis Products: $[NH(C_6H_4)_2AS]_2O$ & HCl.

41. Corrosive Properties:

Titanium	71° C, 6 months, appeared good.
Stainless Steel	43° C, 30 days, slight discoloration.
Common Steel	43° C, 30 days, covered with rust.
Aluminum Anodized	43° C, 30 days, minor corrosion & pitting.
Aluminum	43° C, 30 days, severe corrosion.

42. Detection Methods and Equipment: For vapor or solid, M19 kit, DPT test.

43. Decontaminants:

a. Personnel. Soap and water.

b. Equipment. Slurry or DS2. Bleaching Powder or DS2 in confined spaces. Aeration is sufficient in the field.

c. Areas.

Terrain: Earth moving equipment. STB slurry applied by M9 or M12A1 Decontaminating Apparatus.

44. DOT Classification: Irritating Material.

45. Stabilizer Utilized: None.

46. Types of Containers Required for Storage:

Koresite	
Teflon	unaffected, 3 months
Kynar	at 71° F.

Stable in steel when pure. After 3 months, caused extensive corrosion of aluminum, anodized aluminum, and stainless steel. Will corrode iron, bronze, and brass when moist.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: B

9. Nerve Agents. Nerve agents upset the balance between the sympathetic (adrenergic) and parasympathetic (cholinergic) nervous systems; together, these systems form the autonomic nervous system. Nerve agents react with cholinesterase in an irreversible reaction in tissue fluid to cause accumulation of acetycholine and continual stimulation of the nervous system.

The nerve agents described in this volume are:

GA or EA 1205 (Tabun)

GB or EA 1208 (Sarin)

GB or EA 1210 (Soman)

VM or EA 1664

VX or EA 1701

Next page is blank.

1. Chemical Code or EA Number: GA or EA 1205 (Tabun).

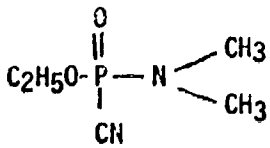
2. Chemical Name: Ethyl N,N-dimethylphosphoramidocyanidate

3. Chemical Formulae:

a. Empirical.

$C_5H_{11}N_2O_2P$

b. Structural.



4. Biological Type Compound: Lethal nerve agent.

5. Principal Pharmacological Action:

GA is an anticholinesterase agent similar in action to GB (q.v.). Although only about half as toxic as GB by inhalation, GA in low concentrations is more harrassing to the eyes than GB.

6. Characteristic Odor: Faintly fruity; none when pure.

7. Effective Routes of Administration: Inhalation, percutaneous, ocular, ingestion, injection.

8. Median Lethal Dosage, Man:

a. Inhalation (LCt_{50}'s). 135 mg min/m^3 (t = 0.5-2 min) at RMV of 15 l/min; 200 mg min/m^3 at RMV of 10 l/min.

b. Percutaneous. Vapor, not known. Probably between 20,000 and 40,000 mg min/m^3. Liquid, LD_{50}, 1-1.5 g/man.

9. Median Lethal Dosage, Animals:

a. Inhalation.

Species	LCt_{50} mg min/m^3
Rat	450 (t = 10)
Rabbit	960 (t = 10)
Dog	320 (t = 10)
Monkey	135 (t = 2)
	187 (t = 10)

b. Percutaneous.

Species		LD_{50} mg/kg	
Rat		12.6	(depilated)
Rabbit		3	(depilated)
Dog	Approx.	45	(depilated)
Monkey		9.3	(shaved skin)

c. Intravenous.

Species		LD_{50} mg/kg
Rat		0.07
Rabbit		0.063
Dog		0.084
Monkey	ca	0.05

d. Intraperitoneal.

Species		LD_{50} mg/kg
Rat	Approx.	0.80
Rabbit	Approx.	2.0

e. Subcutaneous.

Species		LD_{50} mg/kg
Rat	Approx.	0.3
Rabbit		0.3

10. Median Incapacitating Dosage: No data.

11. Threshold Limit Value: No data.

12. Minimum Effective Dosage: Threshold eye symptoms: Ct of 0.9 mg min/ m^3.

13 & 14. Physiological Effects (Acute and Chronic):

The number and severity of symptoms which appear are dependent on the quantity and rate of entry of the nerve agent which is introduced into the body. (Very small skin dosages sometimes cause local sweating and tremors with few other effects.)

Individuals poisoned by GA display approximately the same sequence of symptoms regardless of the route by which the poison enters the body (whether by inhalation, absorption, or ingestion). These symptoms, in normal order of appearance, are: runny nose; tightness of chest; dimness of vision and pinpointing of the eye pupils; difficulty in breathing; drooling and excessive sweating; nausea; vomiting, cramps, and involuntary defecation and urination; twitching, jerking, and staggering; and headache, confusion, drowsiness, coma, and convulsion. These symptoms are followed by cessation of breathing and death.

15. Onset Time of Symptoms: Symptoms appear much more slowly from skin dosage than from respiratory dosage. Although skin absorption great enough to cause death may occur in 1 to 2 minutes, death may be delayed for 1 to 2 hours. Respiratory lethal dosages kill in 1 to 10 minutes, and liquid in the eye kills almost as rapidly.

16. Self Aid and First Aid:

Same as for GB (q.v.).

17. Tolerable Environmental Concentrations to Uncontrolled Population: No data.

18. Molecular Weight: 162.1

19. Purity Range:

a. Laboratory Sample. 88 to 97%.

b. Plant Sample. Not produced.

20. Physical Appearance: Colorless to brown liquid.

21. Vapor Density, Relative to Air: 5.6

22. Liquid Density: 1.08 g/ml @ 25° C.

Tabun

23. Solid Density:

    a. Bulk Density. Not applicable.

    b. Chrystal Density. Not applicable.

24. Normal Freezing Point or Melting Point: -50° C.

25. Boiling Point: 245° C.

26. Vapor Pressure: 0.07 mm Hg @ 25° C.

27. Volatility: 610 mg/m^3 @ 25° C.

28. Viscosity: 2.18 centistokes @ 25° C.

29. Flash Point: 78° C.

30. Autoignition Temperature: Unknown.

31. Latent Heat of Vaporization: 79.6 cal/g @ 25° C.

32. Latent Heat of Fusion: Unknown.

33. Vapor-Air Explosive Hazard Range: Not available.

34. Relative Persistency:

    a. Soil. Approximate half-life, 1 to 1-1/2 days.

    b. Surface (Wood, Metal, Masonry, Rubber, Paint). Unknown.

    c.

Water	Seawater
140 hrs @ 5°	213 hrs @ 5°
42 hrs @ 15°	79 hrs @ 15°
22 hrs @ 20°	45 hrs @ 20°
14-28 hrs @ 25°	29 hrs @ 25°

35. Solubility (g/100 g solvent)

    a. Water (distilled). 9.8 @ 25° C. 7.2 @ 20° C.

    b. Other. Readily soluble in most common organic solvents, e.g., alcohols and ethers.

    c. Best Solvent. Organic solvents.

36. Thermal Decomposition Rate (half-life): Decomposes within 6 months at 60° C. Complete decomposition in 3-1/4 hours at 150° C.

37. Heat of Combustion: -877 kcal/mole (estimated from bond energies).

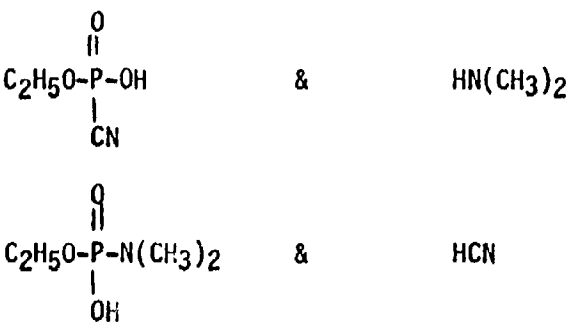
38. Products of Combustion: May produce HCN.

39. Rate of Hydrolysis (specify half-life):

a. Acidic (pH). 8.5 hr @ pH 7, 20° C. 7 hr @ pH 4-5, @ 20° C.

b. Basic (pH). Easily hydrolyzed in alkaline solutions; hydrolysis catalyzed by phosphate.

40. Hydrolysis Products:



41. Corrosive Properties: For Pure GA at 65° C.

2S-1/2 H	Al	6.4×10^{-5} in/yr
3S-1/2 H	Al	0.4×10^{-5} in/yr
52S-1/2 H	Al	6.8×10^{-5} in/yr
61S-T	Al	5.2×10^{-5} in/yr

42. Detection Methods and Equipment: Red Band Tube Test, and Dianisidine-Perborate Test.
Alarm, G Agent, automatic, fixed installation, M5.

For Liquid: ABC-M8 detector paper; M6A1 detector paper.

For Vapor: M15A2, M18A2, M19 kits
(blue band detector tube)
enz e ticket
M8 alarm.

Tabun

43. Decontaminants:

a. Personnel. Flush eyes w/H_2O immediately. Liquid agent on skin may be decontaminated by use of the skin decontamination pad in the M13 kit. M5 Protective Ointment.

b. Equipment. 5 to 10% aqueous caustic. Bleach slurry, dilute alkali, or solutions of DS2. In confined area - steam and ammonia, hot soapy water. May react to form cyanogen chloride in bleach slurry.

c. Areas (Terrain). Aeration. STB slurry applied by M9 or M12A1 decontaminating apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

a. Laboratory Sample. None.

b. Plant Sample.

46. Types of Containers Required for Storage: Crude product is stable in steel and varnished containers at relatively low temperatures. Decomposes within 6 months at 60° C. Distilled product is more stable even under tropic storage conditions.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: A

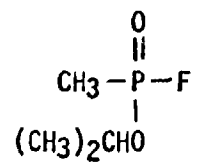
1. Chemical Code or EA Number: GB or EA 1208 (sarin)

2. Chemical Name: Isopropyl methylphosphonofluoridate

3. Chemical Formulae:

a. Empirical: $C_4H_{10}FO_2P$

b. Structural.



4. Biological Type Compound: Lethal nerve agent.

5. Principal Pharmacological Action:

GB is an anticholinesterase compound. Its effects are referable to stimulation of the autonomic and central nervous systems resulting from the inhibition of the acetylcholinesterase enzymes in the tissues and the resultant accumulation of acetylcholine at its various sites of action. These include the endings of the parasympathetic nerves to the smooth muscle of the iris, ciliary body, bronchial tree, gastrointestinal tract, bladder, and blood vessels; to the secretory glands of the respiratory tract; and the cardiac muscle and the endings of sympatheitc nerves to the sweat glands. The accumulation of acetylcholine at these sites results in characteristic muscarine-like signs and symptoms. The accumulation of acetylcholine at the endings of motor nerves to voluntary muscles and in the autonomic ganglia results in nicotine-like signs and symptoms. Finally, the accumulation of excessive actylcholine in the brain and spinal cord results in characteristic central nervous system symptoms.

6. Characteristic Odor: None when pure.

7. Effective Routes of Administration: Inhalation, percutaneous, ocular, ingestion, injection.

8. Median Lethal Dosage, Man:

a. Inhalation (LCt_{50}'s). 70 mg min/m^3 at RMV of 15 l/min (respiratory minute volume); 100 mg min/m^3 at RMV (respiratory minute volume) of 10 l/min (resting man) t = 0.5 - 2 min.

Sarin

b. Percutaneous.

(1) Vapor (LCt_{50}'s). 12,000 mg min/m^3 (bare skin); 15,000 mg min/m^3 (ordinary combat clothing).

(2) Liquid (LD_{50}). 1.7 g/70 kg man.

c. Intravenous injection (LD_{50}). 1 mg/70 kg man.

9. Median Lethal Dosage, Animal:

a. Inhalation.

Species	LCt_{50} mg min/m^3	Exposure time
Housefly	15 (male)	10 min
	25 (female)	10 min
Canary	33 (female)	10 min
Pigeon	37	20 sec
	ca 55	10 min
Mouse	53	2 sec
	137 - 200	5-20 secon
	240 (forced activity)	10 min
	310 (resting)	10 min
Rat	54	2 sec
	220	10 min
Guinea Pig	40	2 sec
	180	10 min
Rabbit	74	1 min
	120	10 min
Cat	22	2 sec
	ca 100	10 min
Dog	19	2 sec
	60	10 min
Pig	34	10 min
Monkey	27	10 sec
	42	2 min
	74	10 min

Sarin

b. Percutaneous.

(1) Liquid.

Species	LD_{50} mg/kg
Mouse	1 (depilated)
Rat	2.5 (depilated)
Rabbit	4.4 (depilated) ca 25 (clipped, 24-hr LD_{50})
Cat	6.2 (depilated)
Dog	10.8 (depliated)
Goat	1.4 (clipped, estival) ca 5.0 (depilated)
Pig	115.9 (clipped)

(2) Vapor.

Species	LCt_{50} mg min/m^3
Rabbit	2000
Monkey	3600 (clipped, 90-100° F, 90-97%, rel. hum.)
	8800 (clipped, 70-80° F, 55-85%, rel. hum.)

c. Intravenous Injection.

Species		LD_{50} mg/kg
Pigeon		0.019
Mouse		0.1
Rat		0.045
Guinea Pig		0.034
Rabbit		0.014
Cat		0.018
Dog		0.019
Goat		0.015
Pig	ca	0.015
Monkey		0.020
Mule		0.050

d. Intramuscular Injection.

Species	LD_{50} mg/kg
Rat	0.112
Rabbit	0.060

e. Intraperitoneal Injection.

Species		LD_{50} mg/kg
Mouse	ca	0.500
Rat	ca	0.250
Rabbit	ca	0.278

f. Subcutaneous Injection. LD_{50}, rabbit: 0.049 mg/kg

g. Ocular Administration.

Species		LD_{50} mg/kg
Pigeon		0.046
Rat	ca	0.125
Rabbit		0.033
Cat		0.041
Dog		0.035
Goat		0.027

h. Ingestion.

Species	LD_{50} mg/kg
Rat	0.870 (starved)
	1.06 (normal)
Rabbit	2.5

10. Median Incapacitating Dosage, Man (ICt_{50}'s):

a. Inhalation.

RMV	15 l/min
0.5 - 2 min. exp.	10-min. exp.
27 mg min/m^3	40 mg min/m^3
37 mg min/m^3	56 mg min/m^3
47 mg min/m^3	72 mg min/m^3

Degree*
Moderate
Severe
Very severe

*Symptoms

Sarin

Symptoms:

Moderate incapacitation: Maximal miosis, eye pain, headache, twitching eyelids, difficulty in accommodation. Chest tightness, runny nose, salivation, sneezing and coughing. Anorexia, nausea, heartburn. Fatigue, weakness, muscle fasciculations, anxiety, and insomnia.

Severe incapacitation: As above, plus diarrhea, frequent urination, dyspnea, ataxia. slow recall, slow reaction.

Very severe incapacitation: Principal effects are convulsions, collapse, and paralysis.

b. Percutaneous. 8000 mg min/m^3.

11. Threshold Limit Value:

No "TLVs" reported by the American Conference of Governmental Industrial Hygienists.

Control limits and ceiling values (as defined below) are based on Biomedical Laboratory data (B. P. McNamara and F. Leitnaker: EASP 100-98, March 1971).

Control Limits and Ceiling Values for GB

Exposure Group	Control designation[a]	Concentration	Maximum Avg. Time	Dose/day	Accumulative Dose
		(mg/m3)		(mg min/m^3)	(mg min/m^3)
Unmasked workers[b]	Ceiling	0.002	NA	NA	NA
	CLWP-1 hr	0.001	1 hr	NA	0.06
	CLWP-8 hr	0.0003	8 hr	0.15	0.15
	CLWP-Ind/10 da	0.0001	10 da	0.05	0.15 x da

a See text below for definitions.
b Health adults medically evaluated and cleared for duty.

a. Selection of Control Limits and Ceiling Values.

(1) Definitions

Because of past misinterpretations of the values recommended as "allowable" airborne concentrations of toxic materials, rigorous definitions of the terms used to identify the values have been established. These are:

(a) Control Limit: This term is defined as the maximum average airborne concentration (mg/m^3) of substances to which it is believed that essentially all members of a specified population can be exposed for a specified period without adverse effect. The period specified may be indefinite. Whether applied to workers or the general population, a definite restriction on maximum upper excursion (ceiling, see below) of concentration and maximum averaging time for indefinite exposure must be specified. For instance:

CLWP-1 hr, -8 hr, etc. = Control limit (mg/m^3) for workers for a 1-hour exposure, an 8-hour exposure, etc. The time period specified is the maximum averaging time.

CLGP-1 hr, -72 hr, etc. = Control limit (mg/m^3) for the general public for a 1-hour exposure, a 72-hour exposure, etc.

CLWP-Ind/5 days = Control limit (mg/m^3) for workers for an indefinite period when the maximum averaging period is five 8-hour days. The maximum averaging period can be different for different toxic materials.

CLGP-Ind/72 hr = Control limit (mg/m^3) for the general public for an indefinite period when the maximum averaging period is three 24-hour days.

(b) Ceiling: This is the concentration that must not be exceeded for any period of time. Ceiling values represent maximum excursions allowable in the averaging period and are, in general, twice the average concentration that could be tolerated safely for 1 hour, provided the average concentrations specified for longer periods of time are also not exceeded.

12. Minimum Effective Dosage, (Effective Ct_{50}, Miosis, Man):

Between 2 and 4 mg min/m^3.

Sarin

13. Acute Physiological Effects:

Site of action	Signs and symptoms
	Following Local Exposure
Muscarine-like-	
Pupils	Miosis, marked, usually maximal (pinpoint), sometimes unequal.
Ciliary body	Frontal headache, eye pain on focusing, slight dimness of vision, occasional nausea and vomiting.
Conjunctivae	Hyperemia.
Nasal mucous membranes	Rhinorrhea, hyperemia.
Bronchial tree	Tightness in chest, sometimes with prolonged wheezing expiration suggestive of bronchoconstriction or increased secretion, cough.
	Following Systemic Absorption
Bronchial tree	Tightness in chest, with prolonged wheezing, expiration suggestive bronchoconstriction or increased secretion, dyspnea, slight pain in chest, increased bronchial secretion, cough, pulmonary edema, cyanosis.
Gastrointestinal	Anorexia, nausea, vomiting, abdominal cramps, epigastric and substernal tightness (cardiospasm) with "heartburn" and eructation, diarrhea, tenesmus, involuntary defecation.
Sweat glands	Increased sweating.
Salivary glands	Increased salivation.
Lacrimal glands	Increased lacrimation.
Heart	Slight bradycardia.
Pupils	Slight miosis, occasionally unequal, later maximal miosis (pinpoint).

Ciliary body	Blurring of vision.
Bladder	Frequency, involuntary micturition.

Nicotine-like-

Striated muscle	Easy fatigue, mild weakness, muscular twitching, fasciculations, cramps, generalized weakness, including muscles of respiration, with dyspnea and cyanosis.
Sympathetic ganglia	Pallor, occasional elevation of blood pressure.
Central nervous system	Giddiness, tension, anxiety, jitteriness, restlessness, emotional lability, excessive dreaming, insomnia, nightmares, headaches, tremor, withdrawal and depression, bursts of slow waves of elevated voltage in EEG, especially on overventilation, drowsiness, difficult concentration, slowness on recall, confusion, slurred speech, ataxia, generalized weakness, coma, with absence of reflexes, Cheyne-Stokes respirations, convulsions, depression of respiratory and circulatory centers, with dyspnea cyanosis, and fall in blood pressure.

14. Chronic Physiological Effects:

a. Acute Exposure.

If recovery from nerve agent poisoning occurs, it will be complete unless anoxia or convulsions have gone unchecked so long that irreversible central nervous system changes due to anoxemia have occurred.

b. Chronic Exposure.

The inhibition of cholinesterase enzymes throughout the body by nerve agents is more or less irreversible, so that their effects are prolonged. Until the tissue cholinesterase enzymes are restored to normal activity, probably by very slow regeneration over a period of weeks or 2 to 3 months if damage is severe, there is a period of increased

susceptibility to the effects of another exposure to any nerve agent. During this period the effects of repeated exposures are cumulative; after a single exposure, daily exposure to concentrations of a nerve agent insufficient to produce symptoms may result in the onset of symptoms after several days. Continued daily exposure may be followed by increasingly severe effects. After symptoms subside, increased susceptibility persists for one to several days. The degree of exposure required to produce recurrence of symptoms, and the severity of these symptoms, depend on duration of exposure and time intervals between exposures. Increased susceptibility is not limited to the particular nerve agent initially absorbed.

Estimates have been made for the times at which 50% of exposed subjects would be affected (Et_{50}'s) at median incapacitating doses. These are presented below.

Et_{50}	Degree of Effectiveness	ICt_{50}	Exposure Time
min		mg min/m^3	min
1.5	Moderate	27	0.5
3.0	Incap.	27	2.0
6.0		40	10.0
1.0	Severe	37	0.5
3.8	Incap.	37	2.0
7.8		56	10.0
2.0	Very	47	0.5
4.5	Severe	47	2.0
9.5	Incap.	72	10.0
6.5	Death	70	0.5
9.0		70	2.0
13.5		103	10.0

15. Onset Time of Symptoms.

Types of Effects	Route of Absorption	Description of Effects	When Effects Appear After Exposure	Duration of Effects After Mild Exposure	Duration of Effects After Severe Exposure
Vapor, Local	Lungs	Rhinorrhea, nasal hyperemia, tightness in chest, wheezing.	One to several minutes	A few hours	1 to 2 days
Vapor Local	Eyes	Miosis, Conjuctival hyperemia, eye pain, frontal headache.	One to several minutes	Miosis - 24 hours	3 to 14 days 2 to 5 days
Vapor, Systemic	Lungs or eyes	Muscarine-like, nicotine-like and central nervous system effects. (See 14a above).	Less than 1 min to a few min after moderate or marked exposure; about 30 min after mild exposure.	Several hours	8 days
Liquid, Local	Eyes	Same as vapor effects.	Instantly	Similar to effects of vapor.	
Liquid, Local	Ingestion	Gastrointestinal. (See 14a, above).	About 30 min after ingestion.	3 days	5 days
Liquid, Local	Skin	Local sweating and muscular twitching.	3 min to 2 hours	3 days	5 days
Liquid, Systemic	Lungs	See 14a, above.	Several minutes		1 to 5 days
Liquid, Systemic	Eyes	Same as for vapor.	Several minutes		2 to 4 days
Liquid, Systemic	Skin	Generalized sweating.	15 minutes to 2 hours		2 to 5 days
Liquid, Systemic	Ingestion	Gastrointestinal. (See 14a, above).	15 minutes to 2 hours		3 to 5 days

16. Self Aid and First Aid:

a. General.

The protective mask and hood, if available, must be put on immediately at the first sign of a nerve agent in the air. Stop breathing until the mask is on, the facepiece cleared and checked. The mask should be worn constantly until the absence of the nerve agent in the air is indicated by approved methods, and the "all clear" signal is given.

If a liquid nerve agent gets on the skin or clothing, the individual should continue his mission. When the tactical situation permits, decontamination must be done promptly as described in paragraph b, below. The usual combat duties should then be continued. The contaminated area should be examined occasionally for local sweating and muscular twitching. If these occur, 2 mg of atropine should be injected (by any available device) intramuscularly in an uncontaminated area in the thigh or upper arm. Combat duties should be continued then as systemic symptoms of nerve agent poisoning may not occur or may be mild, if the decontamination was done successfully.

If a drop or splash of a liquid nerve agent gets into the eye, instant action is necessary to avoid serious effects. The eye should be irrigated immediately with water as described in paragraph c, below. As soon as irrigation is completed, the protective mask should be put on. The pupil of the contaminated eye should be watched during the next minute, in a mirror if one is available, or by someone nearby. If the pupil rapidly gets smaller, one syrette or automatic injector of atropine should be injected intramuscularly at once. If the pupil does not get smaller, the ocular contamination was not by nerve agent, and atropine is not needed.

If water or food contaminated with a dangerous amount of nerve agent is taken, colicky abdominal pains, substernal tightness, increased salivation, and perhaps vomiting will occur about 1/2 hour later.

The appearance of symptoms of nerve agent poisoning calls for the immediate intramuscular injection of 2 mg of atropine. Since inhalation will be the commonest route of exposure, the most likely initial symptom will be a feeling of tightness or constriction in the chest. After ocular or cutaneous splash, the initial systemic symptoms may be generalized sweating and muscular twitching followed by nausea and abdominal cramps. After ingestion, the first symptoms are likely to be gastrointestinal.

Exposure to high concentrations of a nerve agent may bring on incoordination, mental confusion, and collapse so rapidly that the casualty cannot perform self-aid. If this happens, the man nearest to him will give first aid.

Severe nerve agent exposure may rapidly cause unconsciousness, muscular paralysis, and cessation of breathing. When this occurs, atropine alone will not save life. Artificial respiration, given as a first aid measure by the nearest man able to do so, must be started immediately and continued until natural breathing is restored or the casualty can be taken over by medical service personnel. An atropine injection increases the lifesaving effectiveness of artificial respiration and should be administered to the casualty as soon as possible, preferably by someone who is not performing the artificial respiration. If possible, the casualty should be placed with his head lower than the rest of his body so that the secretions which collect in the mouth and air passages will drain away. Wiping out the mouth and throat with a finger will help clear the air passages. Artificial respiration is administered as described in paragraph 22a (8) of TM 8-285 dtd January 1968.

If good relief is obtained from the atropine and breathing is free, the soldier should carry on with combat duties. Dryness of the mouth is a good sign; it means enough atropine has been taken to overcome the dangerous effects of the nerve agent. If symptoms of the nerve agent are not relieved, the soldier should proceed to a medical unit when the combat situation permits.

Atropine injections do not relieve the local effects of nerve agent vapor on the eyes. Although the eyes may hurt and there may be difficulty in focusing and headache, the individual should carry on his combat duties. These symptoms are annoying but not dangerous. When conditions permit, the soldier should proceed to a medical unit for local application of 2 percent homatropine ointment to the eyes, if indicated.

b. Skin and Clothing. The M13 individual decontaminating and reimpregnating kit is provided as an emergency means of either decontaminating the individual's skin, outer clothing when subjected to contamination by chemical agent or as a means of reimpregnating his protective liner outfit (liner shirt and trousers, gloves, and socks). Disposable outer garments are removed and discarded if they become contaminated by agent.

Sarin

Note the following safety precaution:

Caution: Do not attempt to decontaminate the face or eyes before donning a protective mask.

(1) Don a protective mask and protective gloves before using the M13 individual decontaminating and reimpregnating kit.

(2) Decontaminate exposed skin areas other than the face immediately after masking.

(3) Use the buddy system to decontaminate skin and clothing areas that cannot be reached or seen by the individual on his own person.

(4) Remove and discard disposable outer garments if they become contaminated by splashes of agent.

(5) Remove and discard the outer layer of the uniform if it is heavily contaminated with wet spots or streaks of agent.

(6) Remove excess powder from clothing and equipment. Before removing the mask, check the surrounding atmosphere with a detector kit (FM 21-41).

(7) Remove contaminated outer garment before entering a shelter.

c. Eyes. Following contamination of the eye with any chemical agent, the agent must be removed instantly. In most instances identity of the agent will not be known immediately. If an individual suspects contamination in eyes or on face, he must immediately obtain overhead shelter to protect him while the following decontamination process is performed:

(1) Remove and open canteen.

(2) Prepare skin pad from M13 kit.

(3) Take a deep breath and hold it.

(4) Remove the mask.

(5) Flush or irrigate the eye, or eyes, immediately with water. To flush an eye with water from a canteen, or other container of uncontaminated water, tilt the head to the side, pull the eyelids

apart with the fingers, and pour water slowly into the eye so that it will run off the side of the face to avoid spread of the contamination. This irrigation must be carried out despite the presence of toxic vapors in the atmosphere. The breath should be held as long as possible and the mouth kept closed during this procedure to prevent contamination and absorption through mucous membranes. The risk of leaving unknown toxic agents in the eye is so much greater than that from exposure to vapors, during the short period of decontamination, that decontamination must be performed.

(6) Use skin pad to decontaminate both the face and the portion of the mask which came into contact with the contamination on the face.

(7) Replace mask and resume breathing.

(8) Never use M5 Protective Ointment or components of the M13 kit in or around the eyes, as they are extremely irritating to the eyes. The decontamination process should be repeated as necessary until the individual is sure that the decontamination of his eyes or face is complete.

d. Summary of Treatment (Lifesaving Measures).

(1) Terminate exposure by masking casualty, removing from contaminated area, decontaminating skin surfaces, and removing contaminated clothing and equipment.

(2) Start artificial respiration immediately, as a first aid measure for the paralyzed, nonbreathing casualty, and continue until natural breathing is restored or life will be lost.

(3) Give a first dose of 2 mg of atropine (one automatic injector or syrette) as a first aid or self-aid measure as soon as symptoms are noted. An additional 4 mg of atropine may be given by any available personnel. Atropine exceeding a total dosage of 6 mg, if required, usually will be given by a medical officer. If the casualty needs more than 6 mg of atropine and circumstances do not permit the evaluation and advice of a medical officer, additional doses of the drug may be given if ordered by the individual in charge. When the M17A1 field protective mask resuscitation system is not available, the chest pressure arm lift (modified Silvester) or Holger-Nielsen methods of artificial respiration may be used, depending on whether the casualty is vomiting or has injured upper extremities. In a contaminated atmosphere, the Holger-Nielsen method is preferred, particularly for cases with mucous drainage into the throat (FM 21-11).

17. Tolerable Environmental Concentrations to Uncontrolled Population:

The following control limits and ceiling values are cited from EASP 100-98 (Item 11, above) and apply to the general population.

Exposure Group	Control designation[a]	Concentration	Maximum Avg. Time	Dose/day	Accumulative Dose
		(mg/m^3)		($mg\ min/m^3$)	($mg\ min/m^3$)
General Population[b]	ceiling	0.0002	NA	NA	NA
	CLGP-1 hr	0.0001	1 hr	NA	0.006
	CLGP-Ind/ 72 hr	0.000003	72 hr	0.005	0.005 x days

a See text (Item 11 above) for definitions.
b People other than workers.

18. Molecular Weight: 140.1

19. Purity Range (average):

a. Laboratory Sample. 90 to 99 wt%.

b. Plant Sample. 94 to 96%.

20. Physical Appearance: Colorless liquid.

21. Vapor Density, Relative to Air: 4.8

22. Liquid Density: 1.09 g/ml @ 25° C.

23. Solid Density:

a. Bulk Density. NA

b. Crystal Density. NA

24. Normal Freezing Point or Melting Point: -56° C.

25. Boiling Point: 158° C.

26. Vapor Pressure: 2.9 mm Hg @ 25° C.

27. Volatility: 2.2×10^4 mg/m^3 @ 25° C.

28. Viscosity: 1.28 centistokes @ 25° C.

29. Flash Point: Does not flash.

30. Autoignition Temperature: Unknown.

31. Latent Heat of Vaporization: 80 cal/g @ 25° C.

32. Latent Heat of Fusion: Unknown.

33. Vapor-Air Explosive Hazard Range: Not available.

34. Relative Persistency:

a. Soil. At temperatures between 5-25° C, persists for 2.5 to 24 hours; in some soils GB may persist for as long as 5 days.

b. Sea Water.

5° C	90 hrs
15° C	25 hrs
25° C	8 hrs

c. Water.

5° C	12500-125	
15° C	3000-30	pH dependent
25° C	750-7.5	(pH 7.0-9.0)

35. Solubility (g/100 g solvent):

a. Water (distilled). Miscible with H_2O.

b. Other. Readily soluble in all organic solvents.

c. Best Solvent. Water.

36. Thermal Decomposition Rate (half-life): Begins to decompose at 130° C; 2 1/2 hrs at 150° C causes complete decomposition.

Sarin

37. Heat of Combustion: 784 ± 18 kcal/mole.

38. Products of Combustion: CO_2, H_2O, H_3PO_4, HF (bomb calorimetry).

39. Rate of Hydrolysis (half-life @ 25° C):

a. Acidic (pH). 47 hrs at pH 6.0;
7.5 hrs at pH 1.8.

b. Basic (pH). 5 hrs at pH 9.0;
37.1 min at pH 9.0 (constant pH);
4.2 min at pH 10.9.

40. Hydrolysis Products: HF under acid conditions; isopropyl alcohol and polymers under alkaline conditions.

41. Corrosive Properties: Storage from 1 to 3 months at 71° C.

1020 steel - practically no attack
3S aluminum - considerable attack
4S aluminum - moderate attack
17S aluminum - moderate attack
24S aluminum - moderate attack
52S aluminum - very slight attack
A52S aluminum - very slight attack
61S aluminum - very slight attack
copper - slight attack
brass - slight attack
magnesium (FS-1) - severe pitting
cadmium plated steel - severe attack
Inconel - negligible attack
K-monel - negligible attack
lead - slight attack
tin - severe attack
solder - surface attack

42. Detection Methods and Equipment: For Liquid: ABC-M8 detector paper; M5 alarm; M6A1 detector paper, Dianisidine-Perborate Test. For Vapor: M15A2A, M18A2, M19 kits (blue band detector tube) enzyme ticket, M8 alarm.

43. Decontaminants:

a. Personnel. Liqui agent on skin may be decontaminated by use of skin decontaminating pad in M13 kit, and by the M5 Protective Ointment. (Do not use in or around eyes.) Flush eyes with water; wash skin with soap and water.

b. Equipment. 5 to 10% aqueous caustic solution. Bleach slurry, dilute alkali solution or DS-2. In confined area, steam and ammonia.

c. Areas. Hot soapy water.

Terrain: Aeration. STB slurry applied by M9 or M12A1 Decontaminating Apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

a. Laboratory Sample. Tri-n-butylamine; diisopropylcarbodiimide.

b. Production Sample. Tributylamine or carbodiimide.

46. Types of Containers Required for Storage:

a. RDT&E Quantities: Glass or steel. Protect from moisture.

b. Stockpile Quantities: Good stability in steel.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: A

Next page is blank.

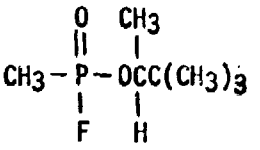
1. Chemical Code or EA Number: GD or EA 1210 (Soman)

2. Chemical Name: Pinacolyl methylphosphonofluoridate.

3. Chemical Formulae:

a. Empirical. $C_7H_{16}FO_2P$

b. Structural.



4. Biological Type Compound: Lethal nerve gas.

5. Principal Pharmacological Action: Anticholinesterase, similar to GB (q.v.).

6. Characteristic Odor: Fruity; with impurities, odor of camphor.

7. Effective Routes of Administration: Inhalation, percutaneous, ocular, ingestion, injection.

8. Median Lethal Dosage, Man:

a. Inhalation (LCt_{50}). 70 mg min/m^3 for man breathing 15 l/min (t = 10 min).

b. Percutaneous (LD_{50}'s). Estimated 0.35 g/man (70 kg) on bare skin. Estimated 1.4 g/man (70 kg) on clothed skin.

9. Median Lethal Dosage, Animal:

a. Inhalation (LCt_{50}'s).

(1) Rabbit. 160 mg min/m^3 (t = 10).

(2) Rat. 230 mg min/m^3 (t = 10), and 279 mg min/m^3 (t = 10).

(3) Mouse. 230 mg min/m^3 (t = 10).

(4) Pigeons. 43 mg/min/m^3 (t = 10).

b. Percutaneous, Clipped Skin, With No Decontamination, (LD_{50}'s).

(1) Dog. 4.93 mg/kg, and 18.8 mg/kg (clothed dogs).

(2) Rabbit. 1.54 mg/kg, and 7.67 mg/kg (clothed rabbits).

(3) Rat. 14.26 mg/kg.

(4) Mouse. 3.46 mg/kg.

c. Subcutaneous (LD_{50}'s).

(1) Rhesus monkey. 0.0070 mg/kg.

(2) Rabbit. 0.016 mg/kg.

(3) Mouse. 0.125 mg/kg.

d. Intramuscular (LD_{50}).

(1) Mouse. 0.140 mg/kg,

e. Intraperitoneal (LD_{50}).

(1) Mouse. 0.225 mg/kg.

f. Intravenous (LD_{50}'s).

(1) Dog. 0.005 mg/kg.

(2) Rabbit. 0.011 mg/kg, and 0.009 mg/kg.

(3) Rat. 0.050 mg/kg.

(4) Mouse. 0.064 mg/kg, and 0.057 mg/kg.

g. Intragastric (LD_{50}'s).

(1) Rabbit. 0.350-0.470 mg/kg (24-72).

(2) Rat. 0.400 mg/kg (24-72 hr).

10. Median Incapacitating Dosage. No official data. Probably in same range as GB (q.v.).

11. Threshold Limit Value: No data; 0.0015-0.002 mg/kg depressed RBC cholinesterase to 30% of normal value when volunteers were injected intravenously.

12. Minimum Effective Dosage. No data.

13., 14., & 15. Physiological Effects and Onset Time of Symptoms: Similar to GB (q.v.).

16. Self Aid and First Aid: Same as GB (q.v.).

17. Tolerable Environmental Concentrations to Uncontrolled Population: No data.

18. Molecular Weight: 182.2.

19. Purity Range (average):

    a. Laboratory Sample. 85 to 99%.

    b. Plant Sample. 93 to 96%.

20. Physical Appearance: Colorless liquid.

21. Vapor Density, Relative to Air: 6.3.

22. Liquid Density: 1.02 g/ml @ 25° C.

23. Solid Density.

    a. Bulk Density. Not applicable.

    b. Crystal Density. Not applicable.

24. Normal Freezing Point or Melting Point: -42° C.

25. Boiling Point: 198° C.

26. Vapor Pressure: 0.40 mm Hg @ 25° C.

27. Volatility: 3900 mg/m^3 @ 25° C.

28. Viscosity: 3.10 centistokes @ 25° C.

29. Flash Point: 121° C. High enough not to interfere with military use.

30. Autoignition Temperature: Unknown.

31. Latent Heat of Vaporization: 72.4 cal/g @ 25° C.

32. Latent Heat of Fusion: Unknown.

33. Vapor-Air Explosive Hazard Range: Not available.

34. Relative Persistency:

    a. Soil. Relatively persistent.

    b. Surface (Wood, Metal, Masonry, Rubber, Paint).

    c. Water. See hydrolysis data.

35. Solubility (g/100 g solvent): Water (distilled). 2.1 @ 20° C, 3.4 @ 0° C.

Soman

36. Thermal Decomposition Rate: Unstabilized sample forms two layers after 4 hours in glass at 130° C. Stabilized sample forms two layers after 200 hours in glass at 130° C.

37. Heat of Combustion: -1253 kcal/mole (estimated from GB value and structural difference contribution).

38. Products of Combustion: Unknown.

39. Rate of Hydrolysis (half-life) 25° C:

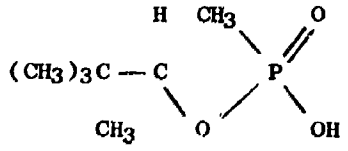
a. Acidic (pH).

3 hrs @ pH2
41 hrs @ pH5
45 hrs @ pH 6.65

b. Basic (pH).

50 hrs @ pH8
60 hrs @ pH10
5 min 5% NaOH SOLN

40. Hydrolysis Products: HF and



41. Corrosive Properties: 1.0×10^{-5} in/mo after storage in steel for 3 months at 65° C.

42. Detection Methods and Equipment: Dianisidine-Perborate Test. M5 Alarm, G-Agent, automatic, fixed installation.

For Liquid: ABC-M8 detector paper; M6A1 detector paper.

For Vapor: M15A2, M18A2, M19 kits
(blue band detector tube)
enzyme ticket
M8 alarm.

43. Decontaminants:

a. Personnel. Flush eyes with water. M13 kit (liquid on skin), M5 Protective Ointment.

b. Equipment. 5-10% aqueous caustic. Bleach slurry and dilute alkali solutions.

c. Areas. In confined area, steam and ammonia. Hot soapy water.

Terrain: Aeration. STB slurry applied by M9 or M12A1 decontaminati apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

a. Laboratory Sample. Diisopropyl Carbodiimide; dicyclohexyl carbodiimide.

b. Production Sample. Same as for laboratory sample.

46. Types of Containers Required for Storage:

a. RDT&E Quantities. Glass.

b. Stockpile Quantities. Steel & aluminum with stabilizer (ICDI); similar to GB in stability.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: A

Next page is blank.

1. Chemical Code or EA Number: VM or EA 1664.

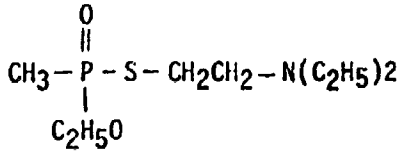
2. Chemical Name: O-ethyl S-(2-diethylaminoethyl)methylphosphonothiolate.

3. Chemical Formulae:

a. Empirical.

$C_9H_{22}NO_2PS$

b. Structural.



4. Biological Type Compound: Lethal nerve agent.

5. Principal Pharmacological Action: Similar to GB (q.v.) but twice as toxic via inhalation route.

6. Characteristic Odor: None.

7. Effective Routes of Administration: Inhalation, percutaneous, ocular, ingestion, injection.

8. Median Lethal Dosage, Man:

a. Inhalation. LCt_{50}: 50 mg min/m^3 for aerosols which have maximum retention (90 to 100%) in respiratory tract. This value is applicable to man breathing 10 l/minute.

b. Percutaneous. No official estimates.

9. Median Lethal Dosage, Animal:

a. Inhalation.

Species	LCt_{50} mg min/m^3
Mouse	8 (t = 1 min) total body exposed
Rat	11 (t = 1 min) total body exposed

Rabbit	ca. 30 (t = 20-40 sec) total body exposed
Dog	13 (t = 10-60 sec) inhalation route

b. Percutaneous.

Species	LD_{50} mg/kg
Guinea Pig	0.15
Rabbit	0.035
Cat	$\leq$ 0.04
Dog	0.050
Goat	0.02
Pig	0.40
Monkey	0.10-0.16

c. Intravenous.

Species	LD_{50} mg/kg
Mouse	$\leq$ 0.02
Rat	$\leq$ 0.02
Guinea Pig	0.0065
Rabbit	0.009
Goat	0.004

d. Subcutaneous.

Species	LD_{50} mg/kg
Mouse	0.035
Rat	0.040

e. Intraperitoneal.

Species	LD_{50} mg/kg
Mouse	0.02 - 0.04

10. Median Incapacitating Dose: No data.

11. Threshold Limit Value: No data.

12. Minimum Effective Dose: No data.

13., 14., & 15. Physiological Effects (Acute and Chronic) and Onset Time of Symptoms: See GB data.

16. Self Aid and First Aid: Similar for GB (q.v.).

17. Tolerable Environmental Concentrations to Uncontrolled Population: No data.

18. Molecular Weight: 239.3.

19. Purity Range:

a. Plant Sample. 83 to 87%.

b. Laboratory Sample. 94 to 96%.

20. Physical Appearance: Water-white to dark yellow.

21. Vapor Density, Relative to Air: 8.3.

22. Liquid Density: 1.0312 g/ml @ 25° C.

23. Solid Density:

    a. Bulk Density. NA

    b. Crystal Density. NA

24. Normal Freezing Point or Melting Point: Below -50° C.

25. Boiling Point: See VX (slightly lower than VX).

26. Vapor Pressure: 0.0021 mm Hg @ 25° C.

27. Volatility: 27.3 mg/m^3 @ 25° C.

28. Viscosity: 5.67 centistokes @ 25° C.

29. Flash Point: 236° C.

30. Autoignition Temperature: See VX, page 177.

31. Latent Heat of Vaporization: See VX, page 177.

32. Latent Heat of Fusion: NA

33. Vapor-Air Explosive Hazard Range: Unknown.

34. Relative Persistency: Relatively persistent.

35. Solubility:

    a. Water (distilled). Miscible below 77° C.

    b. Other. Most organic solvents.

    c. Best Solvent. Dilute mineral acids.

36. Thermal Decomposition Rate (half-life): 125 hours at 100° C, 15 hours at 130° C. (75% decomposed after 90 days in steel at 71° C.)

37. Heat of Combustion: -1948 kcal/mole (estimated from VX value and structural difference contribution).

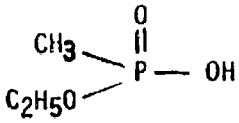
38. Products of Combustion: CO_2, N_2, H_2O, H_3PO_4, H_2SO_4 estimated for furnace incineration.

39. Rate of Hydrolysis:

a. Acidic. 99 days @ 25° C, pH2.

b. Basic. 10 min @ 25° C, 0.1N NaOH.

40. Hydrolysis Products: $HSC_2H_4N(C_2H_5)_2$



$S[-CH_2-CH_2-N(C_2H_5)_2]2$

May produce a toxic product at pH between 7 and 11.

41. Corrosive Properties: Not corrosive to steel or aluminum.

42. Detection Methods and Equipment:

For liquid: ABC-M8 detector paper.

For vapor: M15A2, M18A2, M19 kits
(enzyme ticket)
M8 alarm

43. Decontaminants:

a. Personnel. Hot, soapy water.

b. Equipment. Acidified sodium hypochlorite solution, bleaching solution.

c. Areas(Terrain). STB slurry sprayed from M9 or M12A1 decontaminating apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

a. Laboratory Sample. Carbodiimides.

b. Production Sample.

VM or EA 1664

46. Types of Container Required for Storage

    a. RDT&E Quantities. Glass.

    b. Stockpile Quantities.

47. Q-D Classification: Class 8.
    Compatibility Group: A
    Chemical Group: A

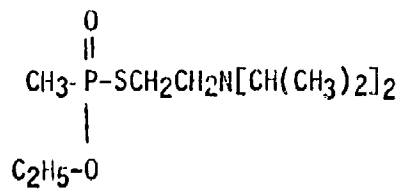
1. Chemical Code or EA Number: VX or EA 1701

2. Chemical Name: O-ethyl S-(2-diisopropylaminoethyl) methylphosphonothiolate

3. Chemical Formulae:

a. Empirical. $C_{11}H_{26}NO_2PS$

b. Structural.



4. Biological Type Compound: Lethal anticholinesterase agent.

5. Principal Pharmacological Action: VX is an anticholinesterase compound similar to GB (q.v.) in mechanism of action and effects. Since VX has a low volatility, liquid droplets on the skin do not evaporate quickly thereby facilatating effective percutaneous absorption. By this route, VX is estimated to be more than one hundred times as toxic as GB for man, LD_{50}'s estimated to be 10 mg/man for VX and 1.7 g/man for GB. By the inhalation route, VX is estimated to be twice as toxic as GB.

6. Characteristic Odor: None.

7. Effective Routes of Administration: Inhalation, percutaneous, ocular, ingestion, injection.

8. Median Lethal Dosage, Man:

a. Inhalation. LCt_{50}: 30 mg min/m^3. Breathing rate of 15 l/min.

b. Percutaneous. LCt_{50}: 6-360 mg min/m^3, small-particle aerosol - (2 u MMD) vapor, masked man, bare skin, windspeed 15-1 mph, respectively.

LCt_{50}: 60-3600 mg min/m^3, same conditions as above, except clothed skin (sateen over cotton).

LCt_{50}: 0.135 mg/kg or 10 mg/man (70 kg).

c. Intravenous. LD_{50}: 0.008 mg/kg or 0.56 mg/man (70 kg).

d. Intramuscular. LD_{50}: 0.012 mg/kg or 0.85 mg/man (70 kg).

9. Median Lethal Dosage, Animal:

a. Inhalation (Vapor).

Species	t	LCt_{50}
	min	mg min/m^3
Mouse (total animal)	10	4.0
(head only)	10	13.6
Goat (total animal)		9.2

b. Inhalation (Aerosol).

Species	t	LCt_{50}
	min	mg min/m^3
Mouse (total animal)	1 (MMD=2.3 μ)	7.0
Rat (total animal)	1 (MMD=1.3 μ	17.0
(total animal)	1	19.5
(head only)	5	8.0
(head only)	10	9.0
Hamster (head only)	-	17
Guinea Pig		
(head only)	-	30
(total animal)	1	44
(head only, windspeed 15 mph, MMD=2 u)	-	8.3
	-	8.4
Rabbit (head only, windspeed 0.01 mph)	-	25
Dog (head only, windspeed 0.01 mph)	-	15
(total animal, clipped, windspeed 5 mph, MMD=2.0-2.3 u)	(5-45 sec)	6.5
(total animal, clipped, windspeed 15 mph, MMD=2.0-2.3 μ)	(5-45 sec)	2.2
Monkey	1	ca 50

c. Percutaneous (Vapor).

Species		t	LCt_{50}
		min	mg min/m^3
Mouse	(body only, unclipped)	10	11.5
Rabbit	(body only, clipped, windspeed 0 mph)	23	28.0
	(body only, clipped, windspeed 8 mph)	24	8.3
Dog	(body only, clipped, windspeed 0 mph)	47	89
	(body only, clipped, windspeed 5 mph)	23	28
	(body only, clipped, windspeed 11 mph)	48	17
	(body only, clipped, windspeed 20 mph)	6	4.6
Goat	(body only, clipped)	-	100-150

d. Percutaneous (Aerosol).

Species		t	LCt_{50}
		min	mg min/m^3
Guinea Pig	(body only, windspeed 15 mph, MMD=2 μ)	-	3.1

Rabbit (body only, depilated windspeed 0 mph, MMD=2-4.5μ)	1	124-180
(body only, depilated, windspeed 0.12 mph, MMD=2-5μ)	-	ca 150
Dog (body only, clipped, windspeed 5 mph, MMD= 2.0-2.3μ)	(5-45 sec)	31.8
(body only, clipped, windspeed 15 mph, MMD=2.0-2.3μ)	(5-45 sec)	3.5

e. Percutaneous (Liquid).

Species	LD50 mg/kg
Rabbit	0.025 0.019-0.033 0.0282 0.0201-0.0395
Dog	0.054 0.040-0.086 ca 0.050
Monkey	ca 0.065
Goat	ca 0.020
Cat	0.0122 0.0074-0.020 > 0.040
Mouse	0.046 0.036-0.059
Rat	0.10 0.069-0.146
Pig	< 0.40 0.38-0.42 ca 0.32

Guinea Pig	$\leq$0.160
	0.035
	0.0246-0.0483

f. Intravenous.

Species	LD_{50} mg/kg
Rabbit	0.0084
	0.0071-0.0099
	0.0084
	0.0074-0.0095
Dog	0.0063
	0.0051-0.0076
Monkey	0.0084
	0.006-0.0119
Goat	$\leq$0.005
Cat	ca 0.0025
Mouse	0.0141
	0.0119-0.0155
	0.0134
	0.012-0.0149
Rat	0.0079
	0.0069-0.009
	0.0086
	0.0073-0.0101
Pig	ca 0.009
	0.009
	0.007-0.011

g. Intramuscular.

Species	LD_{50} mg/kg
Rabbit	ca 0.009
Mouse	0.0173 0.0156-0.0192
Rat	0.0141 0.0124-0.016

h. Subcutaneous.

Species	LD_{50} mg/kg
Mouse	0.0158 0.013-0.0193
Rat	0.0154 0.0119-0.020

i. Intraperitoneal.

Species	LD_{50} mg/kg
Mouse	0.038 0.033-0.0439
Rat	0.0455 0.0373-0.0555

j. Intragastric.

Species	LD_{50} mg/kg
Rat	0.100 0.077-0.1286

10. Median Incapacitating Dose, Man:

a. Inhalation.

ICt_{50}: 24 mg min/m^3. Breathing rate of 15 l/min (80% of LCt_{50})

b. Percutaneous.

Head and neck	1.1 mg/man or 0.0157 mg/kg
Torso	7.7 mg/man or 0.11 mg/kg
Extremities	11.0 mg/man or 0.157 mg/kg
Whole Body	5.0-6.4 mg/man or 0.0714 mg/kg-0.914 mg/kg

11. Threshold Limit Value.

There are no "TLVs" approved by American Conference of Governmental Industrial Hygienists.

Control limits below (as defined in Item 11 for Chemical Agent GB) are based on Biomedical Laboratory data (B.P. McNamara, Frank C. Leitnaker and Frank J. Vocci: EASP 1100-1, October 1971).

Control Limits for VX

Exposure Group	Control designation[a]	Concentration	Maximum Avg. Time	Dosage/day	Accumulative Dose
		mg/m^3		mg min/m^3	mg min/m^3
Unmasked workers[b]	CLWP-1 hr	0.00005	1 hr	NA	0.003
	CLWP-8 hr	0.00002	8 hr	0.01	0.01
	CLWP-Ind/5 da	0.00001	5 days	0.005	0.005xda

a See Item 11 for Chemical Agent GB for definitions of control limits and ceiling values.

b Healthy adults medically evaluated and cleared for duty.

12. Minimum Effective Dose:

Effective dose, gastrointestinal signs 50, at 65-75°F, percutaneous (bare skin) man: 2.2 mg/man or 0.0314 mg/kg.

13., 14., 15. Physiological Effects (Acute and Chronic) and Onset Time of Symptoms:
Similar to GB. Lethal dosages are:

a. Inhalation.

Estimated times to tremors, convulsions, and death in 50% of an exposed population are as follows:

No. of LCt_{50}'s	Tremors	Convulsions	Death
	min	min	min
1.0	10	15.7	27.3
1.25	8.2	11.8	21.6
1.5	6.5	9.3	17.8
2.0	4.5	6.4	13.2
2.5	3.4	4.8	10.5
3.0	2.7	3.8	8.7
3.5	2.3	3.1	7.4
4.0	1.9	2.6	6.4
4.3	1.8	2.4	5.9

b. Percutaneous Absorption.

Bare skin: LD_{50} on bare skin (based on average of total body area) of a 70 kg (154 pounds) resting man in a temperate climate is 10 mg or 135 mmg/kg.

Estimated times to tremors, convulsions, and death of 50% of an exposed population after 1 to 5000 LD_{50}'s are tabulated:

No. of LD_{50}'s	Et_{50} Tremors min	95% Range	Et_{50} Convulsions min	95% Range	Lt_{50} min	95% Range
1	Not recorded		Not recorded		450	(173-1170)*
2	Not recorded		Not recorded		187	(150-239)
5	Not recorded		Not recorded		121	(95-154)
10	43	(31-63)	68	(51-100)	87	(66-114)
100	24	(18-33)	43	(30-60)	-	-
200	-	-	-	-	63	(52-78)
1000	13	(10-20)	28	(18-38)	32	(28-42)
5000	-	-	-	-	20	(16-29)

* 1% die at 54 (16-177) minutes and 16% at 164 (50-539) minutes.

DOSE-RESPONSE DATA FOR MILD SIGNS (NAUSEA OR VOMITING), VERY SEVERE SIGNS (PROSTRATION OR CONVULSIONS), AND DEATH FOR MAN AFTER APPLICATION OF LIQUID VX TO THE VOLAR FOREARM

Population Responding	Dose		
	Mild Signs	Very Severe Signs	Death
%	mg/70 kg man		
1	0.32	1.15	1.44
16	1.37	4.92	6.16
30	2.26	8.1	10.18
50	3.97	14.26	17.87
84	11.6	41.6	52.1
99	48.6	174.0	218.74

16. Self Aid and First Aid: Same as Item 16 for Chemical Agent GB.

17. Tolerable Environmental Concentrations to Uncontrolled Population:

The following control limits are cited from EASP 1100-1 (Item 11, above) and apply to the general population.

Exposure Group	Control Designation[a]	Concentration	Maximum Avg. Time	Dosage/Day	Accumulated Dose
		mg/m^3		mg min/m^3	mg min/m^3
General Population[b]	CLGP-1 hr	0.00001	1 hr	NA	0.0006
	CLGP-Ind/ 72 hr	0.0000003	72 hr	0.0005	0.0005xda

a See text (Item 11 for Chemical Agent GB) for definitions.

b People other than workers.

18. Molecular Weight: 267.4.

19. Purity Range:

a. Laboratory Sample. 86 to 98%.

b. Plant Sample. 94 to 96%.

20. Physical Appearance: Colorless to straw-colored liquid.

21. Vapor Density, Relative to Air: 9.2.

22. Liquid Density: 1.0083 g/ml @ 25° C.

23. Solid Density:

a. Bulk Density. Not applicable.

b. Crystal Density. Not applicable.

24. Normal Freezing Point or Melting Point: Below -51° C; calc. to be -39° C.

25. Boiling Point: 298° C.

26. Vapor Pressure: 0.0007 mm Hg @ 25° C.

27. Volatility: 10.5 mg/m^3 @ 25° C.

28. Viscosity: 9.96 centistokes @ 25° C.

29. Flash Point: 159° C.

30. Autoignition Temperature: Approximately 400° C.

31. Latent Heat of Vaporization: 78.2 cal/g.

32. Latent Heat of Fusion: Not available.

33. Vapor-Air Explosive Hazard Range: Not available.

34. Relative Persistency:

a. Soil. Relatively persistent, 2 to 6 days.

b. Surface (Wood, Metal, Masonry, Rubber, Paint). Persistent.

c. Water. See hydrolysis data. Not readily soluble.

35. Solubility (g/100 g solvent):

a. Water (distilled). 3 at 25° C; 7.5 at 15° C; completely miscible below lower consolute temperature of 9.4° C.

b. Other. Readily soluble in organic solvents.

c. Best Solvent. Dilute mineral acids.

36. Thermal Decomposition Rate (half-life):

295° C 36 sec; 250° C 4 min; 200° C 95 min; 150° C 35 hr; 130° C 160 hr.

37. Heat of Combustion (cal/g): 8,430 $\pm$ 160 cal/g (stabilized VX).

38. Products of Combustion: CO_2, N_2, H_2O, H_3PO_4, H_2SO_4 (bomb calorimetry).

VX or EA 1701

39. Rate of Hydrolysis (half-life, 25° C):

a. Acidic (pH).

40 hrs @ 25° C, pH 7;
100 days @ 25° C, pH 2-3.

b. Basic (pH).

17. hr @ 25° C, pH 11,
2. hr @ 25° C, pH 12,
0.2 hr @ 25° C, pH 13,
1.3 min @ 25° C, pH 14.

40. Hydrolysis Products: Toxic hydrolysis products form at pH's between 7 and 10, i.e., diethyl methylphosphonate, diisopropylaminoethyl mercaptan, ethyl hydrogen methylphosphonate, bis (ethyl methylphosphonic) anhydride, and bis S-(2-diisopropylaminoethyl) methylphosphonodithioate.

41. Corrosive Properties: Negligible on brass, aluminum, and steel.

42. Detection Methods and Equipment: See EA 3580. Same as VM.

43. Decontaminants:

a. Personnel. Hot, soapy water; M5 Protective Ointment.

b. Equipment. STB, slurry, DANC, or DS2 solution.

c. Areas. HOCl or Cl_2 (Bleach), 5-10% solution Na_2CO_3, 5-10% solution NH_4OH or 7% solution of NaOH. Use cold water.

Terrain: STB slurry sprayed by M9 or M12A1 Decontaminating Apparatus.

44. DOT Classification: Poison A

45. Stabilizer Utilized:

a. Laboratory Sample. Dicyclohexylcarbodiimide and diisopropylcarbodiimide.

b. Plant Sample. Same as laboratory sample.

46. Types of Containers Required for Storage: VX is compatible with aluminum, steel, and 316 stainless steel when stored at 71° C for 6 months. VX is not stable at 71° C when stored in 316 stainless steel vials that have been assembled and sealed using silver braze; is stable when welding is by electron beam.

47. Q-D Classification: 8
Compatibility Group: A
Chemical Group: A

Next page is blank.

APPENDIX A

REFERENCES

ACN 16493	Objectives and Systems for Decontaminating in the Field (U), Final Study, US Army CDC, CONFIDENTIAL
AMCR 385-31	Safety Regulations for Chemical Agents H, HD, and HT
AMCR 385-103	Safety Regulations for Chemical Agents GB and VX
AR 380-86	Classification of Chemical Warfare and Biological Research Data (U), FOR OFFICAL USE ONLY
EA PAM 380-2	Security Classification Guide for Chemical Agents and Materiel (U), FOR OFFICIAL USE ONLY
EASP 100-60	Detection of EA 3834, Summary Report of Status, Sept 69, AD506939L
EASP 100-98	Toxicological Basis for Controlling Emission of GB into the Environment, AD 914271L
EASP 1100-R-1	Toxicological Basis for Controlling Emission of VX into the Environment, AD 888814-L
EASP 1200-10	Detection of Hydrogen Cyanide, A Test Readily Adaptable for the XM256 Chemical Agent Detector Kit
ETG-100-41	Vol. I G-Agents Vol. II Blood and Nettle gases Vol. III Vomiting and Choking Gases and Lacrimators Vol. IV. Vesicants
FM 3-8	Chemical Reference Handbook
FM 21-11	First Aid for Soldiers
FM 21-40	Chemical, Biological, Radiological, and Nuclear Defense
FM 21-41	Soldier's Handbook for Defense Against Chemical and biological Operations and Nuclear Defense
SMUEAR 70-4	Chemical Agent and Simulant Data Sheets
TM 3-215 (AFM 355-7)	Military Chemistry and Chemical Agents
TM 3-220	Chemical, Biological, and Radiological (CBR) Decontamination

TM 3-200A (T042C-1-6)	Employment of Toxic Chemical Agents (U), CONFIDENTIAL
TM 3-250	Storage, Shipment, Handling, and Disposal of Chemical Agents and Hazardous Chemicals
TM 8-285	Treatment of Chemical Agent Casualties
TM 750-5-15	Army Equipment Data Sheets, Chemical Weapons and Defense Equipment

INITIAL DISTRIBUTION FOR CHEMICAL AGENT DATA SHEETS

Organization	VOL I	VOL II (C)
Headquarters and Headquarters Co.	1	0
Safety Office	2	1
Surety Office	11	11
USA Tech Escort Center	3	2
Chemical Laboratory	5	5
Biomedical Laboratory	8	8
Development and Engineering Directorate	13	6
Manufacturing Technology Directorate	4	4
Technical Support Directorate	4	2
Product Assurance Directorate	2	2
Pine Bluff Arsenal	5	0
Rocky Mountain Arsenal	5	0
Technical Support Directorate Attn: Technical Releases Division	1	1
Defense Documentation Center	2	2
Development and Engineering Directorate Attn: Technical Publications Branch	5	5

DEPARTMENT OF THE ARMY
US ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND
EDGEWOOD CHEMICAL BIOLOGICAL CENTER
5183 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MD 21010-5424

REPLY TO
ATTENTION OF

RDCB-DPC-RS

FEB 18 2016

MEMORANDUM THRU Director, Edgewood Chemical Biological Center, (RDCB-D/Dr. Joseph L. Corriveau), 5183 Blackhawk Road, Aberdeen Proving Ground, Maryland 21010-5424

FOR Defense Technical Information Center (DTIC), 8725 John J. Kingman Road, Ft Belvoir, VA 22060-6218

SUBJECT: Request for Change in Distribution

1. This action is in response to an Edgewood Chemical Biological Center (ECBC) internal request for a Change in Distribution for the attached listed documents.

2. The listed documents have current distribution statements or classifications which limit their release. ECBC Subject Matter Experts have reviewed the documents and deem them all suitable for the change in distribution to read "Distribution A: Approved for public release; distribution unlimited."

3. The point of contact is Adana Eilo, ECBC Security Specialist, (410) 436-2063 or adana.l.eilo.civ@mail.mil.

Encl

RONALD L. STAFFORD
Security Manager

1. *Report on Properties of War Gases*, Volume 1, G-Agents (U), Chemical Corps Board, Army Chemical Center, MD, **1956**, CONFIDENTIAL Report, (AD-108 456).

2. Rueggeberg, W. H. C.; Ginsburg, A. *The Synthesis of MCE, Cyano (Dimethylamino) Ethoxyphosphine Oxide*, Chemical Warfare Service Technical Data Memorandum Report 1138, **1945** (ADB968799) Dist. "D"

3. Doyle, W. L., et al. *Informal Monthly Progress Report on Toxicity and Irritancy of Chemical Agents, No. N.S. 3*, The University of Chicago Toxicity Laboratory in cooperation with The Medical Division, Chemical Warfare Service, U.S. Army and the Bureau of Medicine and Surgery, U.S. Navy, **1945**. (CBRNIAC-CB-068173) Dist. "E"

4. Panariello, V. Monthly Intelligence Report, 40th Chemical Laboratory Company, April **1945**. (HDIAC-2075468) Dist. "E"

5. Snyder, Jr., H. L.; Hudgin, D. E.; Schlesinger, A. *Captured Material Technical Report #60, New German Chemical Warfare Agent, A Cyano Phosphate*, 44th Chemical Laboratory Company, APO 298, US Army, **1945**. (HDIAC-2075719) Dist. "E"

6. Reuggeberg, W.H.C. *German Agent MCE, Letter Report of Visit to University of Chicago and University of Illinois*, Chemical Division, Edgewood Arsenal, MD, **1945**. (CBRNIAC-CB-114805) Dist. "E"

7. Samuel, J. B.; Penski, E. C.; Callahan, J. J. *Physical Properties of Standard Agents, Candidate Agents, and Related Compounds at Several Temperatures*, UNCLASSIFIED Special Publication ARCSL-SP-83015, U.S. Army Chemical Systems Laboratory, Aberdeen Proving Ground, MD, **1983**, (ADC033491) Dist. "E"

8. Abercrombie, P.L. *Physical Property Data Review of Selected Chemical Agents and Related Compounds: Updating Field Manual 3-9 (FM 3-9)*; ECBC TR-294; U.S. Army Edgewood Chemical Biological Center: Aberdeen Proving Ground, MD, **2003**; Report (ADB294480) Dist. "D"

9. Chemical Agent Data Sheets, Volume 1, EO-SR-74001, Department of the Army, Headquarters, Edgewood Arsenal, Aberdeen Proving Ground, Maryland, **1974**. (CBRNIAC-CB-007206) Dist. C (export controlled)

10. War Department Memorandum, Subject: New German Gas, MCE, Preliminary Report, 19 June **1945**. (CBRNIAC-CB-093876)

Encl